

HOPE FOR COASTAL HABITATS

PEOPLE, PARTNERSHIPS & PROJECTS MAKING A DIFFERENCE



RESTORE
AMERICA'S
ESTUARIES



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Photo: Sunset on Bogue Sound in North Carolina. Courtesy of Cheryl Burke.

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We are, all of us, from the sea. We are continually lured back to its edge to share our kinship with it. Some of us set down stakes. But many come to nourish their youthful spirit by fishing, sailing or swimming. We come to relax by a placid marsh or to admire the sun rising above the ocean's horizon.

And yet, no place on earth more directly embodies the challenge of balancing our own lives with the lives of our fellow species than these special places where the land meets the sea. Here, at the coastline, the ocean reaches out for the land, with estuaries as its fingers and hands. In this unique nexus - characterized by the dynamic mixing of salt and freshwater in tidal cycles - abundant life is created and nurtured. They are renowned for the young fish and shellfish that they rear.

By 2075, it is estimated, three-quarters of our nation will live within 50 miles of the coast. Without delay, we must solve the conundrum of developing coastlines while also protecting and restoring the very habitat that draws us there.

The 11 conservation groups that make up Restore America's Estuaries have committed themselves to preserving and restoring the lands and waters essential to the richness and diversity of coastal life. They have undertaken hundreds of restoration projects as part of a national campaign to restore the health of our nation's estuaries. They have put thousands of volunteers to work remaking marshes, rebuilding shellfish beds or replanting under-water grasses.

In the following pages you will read about people who have made a difference locally. We hope that this publication shows that it can be done. From San Francisco Bay to the Penobscot River in Maine, people are restoring our coast's natural vitality, one river, one bay, one watershed at a time. As the stories that follow show, it takes inspiration, commitment, hard work and, yes, money. But there is still hope for our coastal habitats.

Jeff Benoit

President
Restore America's Estuaries



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RAE MEMBERS

American Littoral Society

Highlands, N.J.
www.littoralsociety.org

Chesapeake Bay Foundation

Annapolis, Md.
www.cbf.org

Coalition to Restore Coastal Louisiana

Baton Rouge, La.
www.crcl.org

Conservation Law Foundation

Boston, Mass.
www.clf.org

Galveston Bay Foundation

Webster, Tex.
www.galvbay.org

North Carolina Coastal Federation

Ocean, N.C.
www.nccoast.org

People For Puget Sound

Seattle, Wash.
www.pugetsound.org

Save The Bay – San Francisco

Oakland, Calif.
www.savesfbay.org

Save The Bay – Narragansett Bay

Providence, R.I.
www.savebay.org

Save the Sound, a program of CT Fund for the Environment

New Haven, Conn.
www.savethesound.org

Tampa Bay Watch

Tierra Verde, Fla.
www.tampabaywatch.org

HOPE FOR HABITATS

Publications like this one are usually depressing. Coastal ecosystems in America are in trouble. Wetlands continue to be filled. Underwater grass meadows continue to disappear. Oyster and clam beds continue to be polluted. Writing about them, then, invariably leads to long lists of statistics that catalog the losses. The accompanying downward trending charts reinforce the numbers. They all combine to leave readers numb and feeling hopeless.

This isn't one of those kinds of publications. You will find plenty of bad news in the following pages. It's unavoidable, given the state of our coastal habitats. Our goal here, however, isn't to highlight what we've lost, but to celebrate what we're winning back. This isn't a publication about destruction and despair; it's more about restoration and rejuvenation.

You'll find 12 stories on the following pages. They are mainly about ordinary people who were inspired to save a piece of our coast's disappearing natural heritage. You'll read about Harry Lester of Virginia, for instance. His memories of eating oysters from the Lynnhaven River drove him to start a movement that reclaimed some of the polluted river back for the oysters. Then there are the Chums of Barker Creek. The small citizens group had formed to clean up the imperiled urban creek that flows into Puget Sound near Bremerton, Wash. Its work eventually led to the removal of a highway culvert that reopened miles of historic spawning grounds for salmon and trout. You'll also meet Phil Sander and Al Krampert. The two strangers were drawn together by their love of America's fast-disappearing prairies. They ended up working together tirelessly for 40 years to save what is now the last untouched prairie on the shores of Lake Michigan, maybe the last one in the entire Midwest.

These stories have common threads. All are about people moved by their memories and desires to ignore the grim statistics and downward trends and take action to reverse them, at least in their small parts of the coast. Many of the stories illustrate the complex partnerships among government agencies, non-profit and citizen groups, corporations and universities that are now often required to save a marsh or reclaim a river.

Money, of course, was an essential ingredient all of the restoration projects. Inspiration will get you just so far. So, many of these stories feature grant programs from the National Oceanic and Atmospheric Administration (NOAA), which provide the necessary money that allows

DAMAGES TO OUR HABITATS

Our activities can have dramatic and sometimes destructive effects on vital coastal habitats. Here are just a few of the major ways:

- Altering the landscape directly, such as draining wetlands, dredging though shellfish beds or bulldozing sand dunes.
- Contaminating water with bacteria and toxic substances from stormwater that runs off roads, parking lots and other types of constructed surfaces.
- Polluting water with excessive nutrients from agricultural and home fertilizers and from domestic sewage.
- Building dams on rivers, which block fish from migrating up or downstream.



SEAHORSE & SEAGRASS © Jeff Jeffords, www.divegallery.com

people to put their inspirations to work. NOAA's Office of Habitat Conservation's work runs the gamut from protection to restoration; this publication highlights some of the successful restoration efforts. Since 1996, those grants have funded nearly 2,000 projects that have restored over 60,000 acres of coastal habitat and reopened more than 2,600 miles of streams to migrating fish. Since 2005 alone, NOAA provided an estimated \$50 million to support nearly 800 projects to restore coastal fisheries habitat.

You'll also see Restore America's Estuaries mentioned often in the stories. The non-profit coalition of 11 conservation groups across the country is committed to restoring our nation's estuaries, one community, one estuary, one project at a time. Founded in 1995, Restore America's Estuaries has raised tens of millions of dollars for more than 1,000 community-based habitat restoration projects nationwide. RAE has mobilized more than 250,000 volunteers, and restored tens of thousands of acres of coastal habitat across the country.

Make no mistake; we're not attempting to sugarcoat reality. The transformation of our coasts began when the first humans set down stakes along them, but the degradation is accelerating at an alarming rate as more and more Americans move to the water's edge. Scientists studied 12 once-productive and naturally diverse estuaries, including San Francisco Bay, Galveston Bay, Chesapeake Bay and Massachusetts Bay, and reported in 2006 that human development has depleted more than 90 formerly important species, destroyed 65 percent of seagrass and wetland habitat and severely degraded water quality.

Carlos Duarte, a researcher at the Spanish Council for Scientific Research, noted at a conference of biologists in 2007 that the story is the same all over the world. "Coastal habitats," he said then, "are disappearing at a rate of between 1.2% and 9% a year and are now the biosphere's most imperiled systems, with rates of loss four to ten times faster than those of the tropical rainforest."

The problems are real and will likely get worse as our climate changes this century. But despair won't improve things. Instead, this publication takes Christy Everett's advice. She works for the Chesapeake Bay Foundation. You'll meet her later. "Things aren't perfect and we will all have to do more," she says. "But you have to show people that you can slow the pace of deterioration, that they can make a difference. You have to give them hope."

A Tally of Habitat Losses

NATIONWIDE*

- At current rates of coastal development, more than one-quarter of the nation's coastal lands will be altered by 2025.
- More than 60 percent of our coastal rivers and bays are moderately to severely degraded by nutrient runoff.
- More than 13,000 beaches were closed or under pollution advisories in 2001, an increase of 20 percent from the previous year.
- In the U.S., a sea level rise of one foot could eliminate 17–43 percent of today's wetlands.

PACIFIC NORTHWEST

- Washington: 50 to 90 percent riparian habitat lost or extensively modified since early 1800s.
- Oregon: Nearly half of historic tidal wetlands lost.
- Alaska: More than half of culverts obstruct fish passage; Exxon Valdez oil spill contaminated 1,500 miles of coastline in 1989.

CALIFORNIA

- San Francisco Bay: 95 percent of historic wetlands and riparian habitat damaged or destroyed.
- Southern California: Estuarine wetlands eliminated by 75 to 90 percent.

PACIFIC ISLANDS

- Hawaii: Coastal plain wetlands decreased by 31 percent over a 200-year period.
- Saipan and American Samoa: 64 percent and 25 percent of estuarine wetlands lost, respectively.

GREAT LAKES

- More than two-thirds of wetlands filled or drained.
- Southeast Michigan: 90 to 97 percent of original emergent coastal wetlands lost.
- Detroit River: 87 percent of river's U.S. shoreline filled and bulkheaded.

NORTHEAST

- About 90 percent of coastal marshes ditched to control mosquitoes by 1930s.
- Maine: Only 52 percent of spawning and nursery habitat for Atlantic salmon remains.
- Narragansett Bay: 33 percent of shellfish beds closed to harvest due to pathogens.
- Long Island Sound: Tidal wetlands decreased by more than 35 percent over the past century, and beds of submerged aquatic vegetation decreased by 65 percent since the 1950s.

MID-ATLANTIC

- Delaware Estuary: More than 25 percent of historic wetlands lost and more than a third of tidal wetlands invaded with *Phragmites*.
- Chesapeake Bay: 60 percent of historic wetlands, 88 percent of submerged grass beds and 98 percent of native oyster reefs lost.

GULF COAST

- Most estuaries lost 20 to 100 percent of seagrass habitat.
- More than half of oyster-producing areas permanently or temporarily closed.
- Louisiana: Marsh the size of a football field lost every 30 minutes since 1930.
- Tampa Bay: Nearly 80 percent of seagrass and half of salt marsh and mangrove habitat lost.

SOUTHEAST

- From European settlement to 1980, 78 percent of wetlands lost.
- Nearly half of protected barrier island beaches and dunes and intact saltwater and freshwater marshes have also been lost.
- South Carolina: About one-third of shellfish areas permanently closed.
- North Carolina: Almost 68,000 acres of shellfish beds permanently or temporarily closed.

* Stedman, S. and T.E. Dahl. 2008. Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service.

HABITAT IS HOME

Animals and plants aren't much different from us in their needs. They need shelter, sources of food, and mates to live with and reproduce. And like us, some require specific kinds of food and shelter while others tolerate a wider range of conditions. To them, "habitat" is merely a fancy name for home.

Their homes, like ours, come in many varieties: windswept dunes and waving strands of underwater seagrasses, saltwater marshes that fringe the marine shoreline and inland tea-colored swamps, beds of clams and reefs of oysters. Surrounding it all is the water itself, the essential ingredient that sustains all the other habitats. Each one is connected to the other, and they interact to form coastal "ecosystems".

Many animals live in these ecosystems and depend on different types of habitats at different times in their lives. Some species of fish, for instance, spend their early lives in salt marshes where the shallow, nutrient-rich water provides plenty of food

and offers a haven from many predators. Later in life, these same animals move into the ocean where they prowl deep-water reefs as predators themselves.

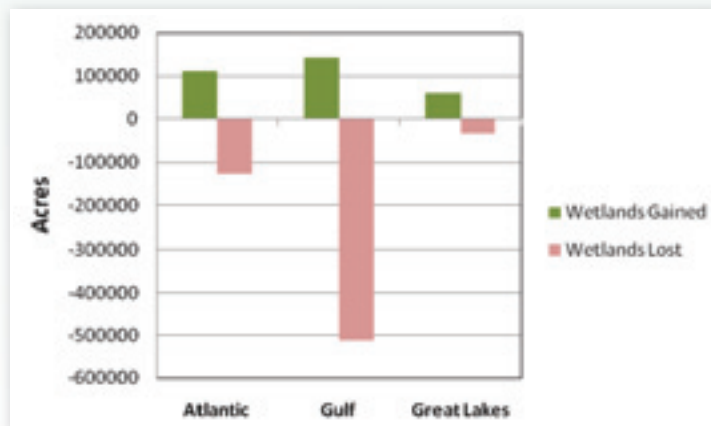
Abundant and healthy coastal habitats make for healthy fish populations. Our coastal marshes produce more tons of vegetation per acre than the rich agricultural lands of the Midwest. As a result, coastal estuaries teem with life. Waters far from land and not enriched by nutrients carried to the ocean by rivers generally are not as productive, animal life not as abundant. Thus, nearshore coastal waters support larger populations of fish and shellfish because nutrients and shelter are more available. Almost one-half of the fish caught in the United States are caught within three miles of shore. More than 90 percent of the fish that support our country's commercial and recreational fishing industries spend at least part of their lives in the various habitats that make up our coastal estuaries. These habitats, then, are the most productive part of the marine and lake environments, and they are becoming increasingly vulnerable to our neglect.

WETLANDS: The Sinks and Faucets of the Coast



William Byrd led the party that surveyed the North Carolina-Virginia state line through the Dismal Swamp in 1728. He summed up what most settlers of America's coast thought of the vast stretches of marshes, swamps and bogs that confounded them.

"Never was rum, the cordial of life, found more necessary than it was in this dirty place," Byrd wrote in his history of the survey.



WETLAND GAINS AND LOSSES IN THE COASTAL WATERSHEDS OF THE ATLANTIC, GULF OF MEXICO, AND GREAT LAKES, 1998 TO 2004. *Stedman, IBID*

WHY RESTORE WETLANDS?

Here's a list of just some of the reasons:

- Slow floodwaters
- Protect uplands from erosion
- Improve water quality
- Provide setting for recreation and study
- Help maintain strong economy
- Provide habitat for many fish, wildlife and plant species (Many endangered species inhabit wetlands or wetlands play an important part of their life cycle)
- Recharge groundwater
- Produce products used by humans: timber, peat, fish, rice, cranberries, blueberries, hay for livestock

What we now call "wetlands" were considered wastelands in Byrd's day. They were thought to be unhealthy and, thus, were avoided and given names like "Dismal." The only good swamp, Byrd and his contemporaries concluded, was a drained one.

Until rather recently, the most productive use of a swamp or marsh, it was thought, was as a soybean field, a housing development or a shopping center.

We now know and understand more about wetlands, of course. We know, for instance, that an acre of salt marsh can be more productive than an acre of corn, and we now understand that without wetlands our coastal estuaries and the abundant sea life they support wouldn't exist.

THE BENEFITS

Generally, a wetland is an area that is flooded by water frequently enough to support plants that live in wet soil. Along coastal shorelines, that broad definition embraces such diverse ecosystems as salt marshes that fringe sounds and bays to inland shallow depressions that periodically fill with rainwater.

Each type of wetland is important in keeping our coastal estuaries healthy. The salt marshes, for instance, provide food and sanctuary to countless creatures, from marsh periwinkles to Canada geese. Songbirds depend on wet prairie potholes near the Great Lakes to survive their continental migrations.

The large expanses of shallow water and thick vegetation found in wetlands provide abundant food and cover for the young of numerous creatures, making the marshes the nursery for many species of fish, shellfish and other critters.

Inland, wetlands trap stormwater long enough to allow pollutants and debris to settle out before they reach coastal waters. Such wetlands also help recharge freshwater aquifers that so many people depend on for their drinking water.

Wetlands can also be important natural areas, supporting rare plants and animals. And scientists are just beginning to understand how wetlands help filter water and move it around the estuary. They are the sinks and faucets in the estuary's plumbing system -- holding water or slowly releasing it.

THE TRENDS

We didn't always know the importance of wetlands. For much of our history, Americans have done their best to drain and fill what we judged to be wet, worthless places. How well we've done the job is hard to accurately gauge. Estimating historic wetland losses is difficult because definitions of wetlands have changed over time; methodologies and mapping techniques have differed.

But the U.S. Department of the Interior, in an exhaustive report to Congress in the late 1980s, made an effort to determine the amount of wetlands lost in America since colonial times. It determined that more than half of the 221 million acres of wetlands that colonists found in what would become the lower 48 states were gone by the 1980s. In more than 20 states more than half of the wetland acres were lost. Some states had lost almost all their wetlands. States around the Great Lakes, like Indiana and Illinois, had lost more than 80 percent of their wetlands. You will read later about a project to protect a prairie wetland on Lake Michigan. California lost 91 percent of its wetlands. The losses, the report noted, meant that the lower 48

states lost an average of 60 acres of wetlands every hour for 200 years.

Similar estimates done since the late 1980s have found that while the rate of loss has slowed, wetlands are still being destroyed. Watersheds along the Atlantic and Gulf coasts lost more than 360,000 acres of wetlands between 1998 and 2004, according to a study released in 2009 by NOAA and the U.S. Fish and Wildlife Service. These continued losses come almost two decades after President George H.W. Bush committed the country to a “no net-loss” policy on wetlands.

THE THREATS

Historically, most wetlands were drained and converted to cropland, pastures and forests. In California, for instance, almost 700,000 acres of wetlands were turned into rice fields. But the U.S. Fish and Wildlife Service attributed almost 80 percent of the recent losses of freshwater wetlands in the Atlantic and Gulf coast watersheds to development activities. The regions contain some of the fastest-growing counties in the country, as more and more people flock to the water’s edge to live or vacation.

The report ends with a warning:

“The results of this study suggest that wetland protection and restoration require more attention in coastal watersheds... Public policymakers and coastal managers have been confronted with the daily task of finding a balance between benefiting from economic growth and mitigating the effects of growth on coastal environments. This task will become more challenging as the coastal population continues to grow in a limited space, thereby exacting more pressure on the remaining natural habitats, including wetlands.”

WETLANDS AND CLIMATE CHANGE

Wetlands on China’s Qinghai-Tibet plateau have shrunk by more than 10 percent over the past 40 years, posing a threat to agriculture and river flows. Scientists from the Chinese Academy of Sciences blame global warming. Though more rainfall is falling on the plateau, they say, water flow to the region’s river has decreased because of increased evaporation from higher temperatures.

Climate change will have a similar effect on wetlands in the United States, scientists say. Flooding from rising seas will inundate many coastal wetlands. The Pew Center on Global Climate Change estimates that a 1.5-foot rise in sea level brought on by melting glaciers and ice caps - which many climate scientists consider a conservative outcome of a warming climate - would flood about 46,000 square miles of coastal wetlands - or an area equal in size to Pennsylvania. A five- to seven-foot rise could mean the loss of 30 percent to 80 percent of coastal wetlands, the U.S. Environmental Protection Agency estimates.

The Association of State Wetland Managers issued a draft report in early 2009 that predicted that increased temperatures and increases or decreases in precipitation will have severe effects on wetland ecosystems. The effects will be particularly great on coastal and estuarine wetlands, which cannot migrate inland because of steep topography, levees, seawalls or other development. The effects will also be significant for small, shallow wetlands such as vernal pools and prairie potholes, where temperatures and evaporation rates may substantially increase without corresponding increases in precipitation. Compounding this in coastal areas will be the likely increase in tropical storms and heavier and more abundant rainfall bringing increased freshwater and sediment. Changes in the hydrological cycle will affect inland wetlands too and test their abilities to contend with increased rainfall in some areas and decreased rainfall in others as well as changes in groundwater recharge and discharge.

Wetland Restoration at North River Farms

After the bears mauled the water sampling machines for the third or fourth time, the scientists decided to put up the electric fence.



VOLUNTEERS PLANT ONE OF THE TENS OF THOUSANDS OF TREES THAT WERE USED TO TRANSFORM THE FARM *Courtesy of the N.C. Coastal Federation*

The paw prints were a good sign. They meant that the bears had found the newly restored wetlands to their liking, but the wreckage of expensive machines had to stop.

Monitoring water quality is an important way of tracking the progress of the wetland restoration project on the North River in eastern North Carolina. Scientists had to document how much agricultural runoff the new wetlands removed from runoff entering the river and neighboring Ward Creek. So the curious bears had to be constrained. The electric fence did the trick.

Bears, bobcats, deer, coyotes, raccoons, a myriad of birds and blue crabs and other aquatic life have all been showing up in growing numbers since the N.C. Coastal Federation and its partners bought and started restoring North River Farms on North Carolina’s central coast about a decade ago.

North River Farms is the largest wetland-restoration project ever attempted in North Carolina. When it’s complete, the federation and its partners will restore about 6,000 acres of wetlands and streams. Turning the farm fields back to wetlands is expected to benefit the rich fishing waters of North River and Core Sound.

The runoff from North River Farms and the adjacent, 44,000-acre Open Grounds Farm is the main reason for the high levels of bacteria that forced the state to close shellfish beds in part of the river and several adjacent creeks. The restoration project’s goal is to restore the land’s natural drainage, which should improve water quality and should eventually lead

to the reopening of shellfish waters.

The newly created wetlands replace farm fields that were contributing pollutants to the river. They will also slow down and treat the contaminated runoff from Open Grounds Farm that flows through the project site. In the re-created wetlands, the runoff will soak into the ground or slowly meander through re-created streams that mimic what was there before the land was



TOP LEFT: WETLANDS ALONG NORTH RIVER WERE FILLED AND LINED WITH DITCHES TO CREATE FIELDS TO GROW SOYBEANS, WINTER WHEAT AND POTATOES. *Courtesy of the N.C. Coastal Federation* TOP RIGHT: BULLDOZERS BEGIN THE RESTORATION BY TURNING THE UNIFORM FARM FIELDS INTO A MAZE OF FURROWS, HOLES AND HILLS THAT ARE MEANT TO MIMIC THE RANDOMNESS OF NATURE. *Courtesy of the N.C. Coastal Federation* BOTTOM: VOLUNTEERS PRUNE YOUNG BALD CYPRESS THAT WERE PLANTED AT THE FARM *Courtesy of the N.C. Coastal Federation*

IMPROVING WATER QUALITY OPENS PORTIONS OF NORTH RIVER

Restoring wetlands at North River Farms may have paid early dividends in 2006, when the state opened portions of the river that had been closed to shellfishing for decades.

The N.C. Division of Marine Fisheries opened 209 acres of previously closed oyster beds in North River and Ward Creek, a tributary of the river. State inspectors found that bacteria levels had dropped enough to safely reopen portions of the river.

The action came after several hundred acres of wetlands had been restored at North River. This is a welcome trend. As restoration work continues, the project's partners are hoping for more good news, and more oysters.

ditched and turned to farm fields in the 1970s and '80s. Much of the bacteria and other pollutants will be naturally removed before entering the river.

"At the time this land was ditched and drained, no one realized how much impact runoff had on downstream water quality," said Todd Miller, the federation's executive director. "Now we know that good water quality and healthy fisheries depend on wetlands, and this project will provide a big sponge in the headwaters of coastal waters that should become cleaner and more productive."

But, first, a sizable tract of land had to be bought. Putting together the diverse partnership required to buy the farm and undertake a restoration of this size was a complex effort of its own that involved some unlikely bedfellows. The federation bought several parcels with money from the state Clean Water Management Trust Fund in 1999 and began restoration activities with grants from NOAA's Community-based Restoration Program and Restore America's Estuaries. The partnership kept expanding. The list now includes the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, N.C. State University, Duke University, farmers, private foundations and investors, a hunting group, a private mitigation land bank, students and local residents. All bring sweat equity, money or both to the effort.

Volunteers – sometimes local, sometimes from places as far away as the corn belt of Iowa – have worked for thousands of hot sweaty hours to plant hardwood trees and wetland grasses or build oyster reefs from recycled shells. Students by the droves come to the site for hands-on examples of what they're learning in science class.

The latest transformation of the land is occurring with the help of some of the same people who changed it the first time. Sarah King, the federation staff member who managed the project from 2004-2007, remembers an encounter she had out at the farm one day when she was leading a tour.

"I was taking them through the project at an interpretive sign right by the farm entrance," she recalled. "Midway through, a pickup truck pulled up and a gentleman got out.

"He asked what we were doing, and if we were part of the work that was going on here. I wasn't sure what he thought about it, but I said, 'Yes, I was with the Coastal Federation and it was our project.'"

Then King got a pleasant surprise. "He came up and told us that he was so happy we were doing it. He wanted to get involved and help any way he could. He was great."

It turns out that Eric Pake Jr., the man who showed up and joined the tour that day, had a long history with the farm. Helping to drain and clear the farm was his first job out of high school in the 1980s.

As an adult, Pake went on to take up fishing, and over time watched with dismay as both water quality and the catches declined. He realized that something had to be done to clean up the water if the fishing was to revive.

That's why he was thrilled when he heard efforts were being made to restore the farm. "I love this place and what the Coastal Federation is doing here has already made a difference in the water quality of North River," he told the *Carteret News-Times* in 2005.

He continues to work on the restoration, and he's gotten his two teenaged daughters involved, as well. "It's helped everything in the quality of the North River," he explained. "I've been told by the old-timers that the oysters are back like they were in the '50s and '60s, big as your hand. And now we can take them from the water in some places. And puppy drum, they feed around oyster rocks—they're back, too."

Chiwaukee Coastal Prairie

The sight of the great American prairie astonished early explorers sailing along the western shore of Lake Michigan. Unending fields of tall grass came down to the water's edge, trampled in spots by wandering bison. The ground was covered by a riot of blooming native wildflowers. Their colors depended on the season – yellow puccoon and purple shooting stars in the spring, black-eyed susans and golden coreopsis in the summer and a grand show of goldenrods, asters and red, gold and brown Indian grass in the fall. Aldo Leopold, one of America's great naturalists and himself a native of the prairies, would later call it the “calendar of colors.”

That prairie along the lake shore is gone now, as are most of the others. The prairie that stretched across half a continent, that was celebrated in Woody Guthrie songs and in John Wayne westerns, has been so thoroughly plowed and ditched, paved and cut that less than one half of one percent of the original still remains. It is one of the truly imperiled ecosystems in the world, and with it has gone the song birds, the mammals and the plants that had depended on it. Along the heavily urbanized lake shore north of Chicago, the old prairie now sprouts pavement and masonry, glass and steel.

But there is a place, just across the Wisconsin line, where a remnant of the virgin prairie still exists. South of Kenosha in a township fittingly called Pleasant Prairie, the calendar of colors still blooms.

The Chiwaukee Prairie, a long, narrow treeless tract along the lake's shore, has never been plowed, planted or successfully drained, though some have tried. Local activists saved the first few acres from the bulldozers in the mid-1960s. Since then, a coalition of local people, college professors, conservation groups and state agencies has worked assiduously to piece together plot by plot the rest of the almost 600 acres that are now preserved as one of the largest prairie complexes in the state and the most intact coastal wetland in southeastern Wisconsin.

“This was one of the first projects in the state of Wisconsin where a volunteer coalition of people got together to really protect a place,” noted Steve Richter, a director of conservation in Wisconsin for The Nature

TALL STANDS OF NATIVE GRASSES AND BLUE SKIES OFFER A STUNNING CONTRAST ON THE CHIWAUKEE PRAIRIE. © Barbara J. Slane, courtesy of the Wisconsin Chapter of The Nature Conservancy

Conservancy. “People were a big part of this.”

But, first there was the ice. The Chiwaukee is a gift of glaciation. It formed about 13,000 years ago when Lake Chicago, the predecessor of Lake Michigan, receded. The prairie is really an old beach covered by a thin layer of topsoil. The wind and waves of the receding lake left behind a series of sand dunes that now support an amazing variety of plants, noted Dr. Eugene C. Gasiorkiewicz, a retired botany professor at the University of Wisconsin's campus in nearby Parkside.

“You have these undulating sand bars and you have different species of plants at one level where there are wet sinks and other species in drier areas as you climb the grade,” he said. “It makes for a very unique habitat.”

Chiwaukee Prairie - #54



More than 400 species of vascular plants have been found here. The variety of habitats, coupled with their location in the extreme southeastern corner of the state, allows several rare and geographically restricted plants, amphibians, reptiles, birds, invertebrates and mammals to thrive here. Twenty-six rare plant species, 10 of which are listed as endangered or threatened, grow in the prairie. Rare plants include smooth phlox (*Phlox glaberrima* ssp. *interior*), Ohio goldenrod (*Solidago ohioensis*) and marsh blazing star (*Liatris spicata*). Rare animals include Blanding's turtle (*Emydoidea blandingii*) and the silphium borer moth (*Papaipema silphii*). Because of this extraor-

dinary diversity, Chiwaukee Prairie was recognized as a National Natural Landmark by the National Park Service in 1973.

Pam Holy grew up around the prairie. She's now president of the Chiwaukee Preservation Fund, Inc., a non-profit group that is descended from the committee of activists that began efforts to save the prairie. "We're the hands-on group for the prairie," she says. "We're out there frequently doing whatever needs to be done."

They diligently remove invasive species, such as clover and buckthorn. They pick up trash and cut fire breaks for the controlled fires that The Nature Conservancy conducts to maintain the prairie. When they're not getting dirty, the group's members are leading birding trips or holding workshops on the lichen of the prairie.

"They're out on the land all the time," Richter said. "They're proud of what they do, and they're proud of the prairie. Having people involved like that is the reason why this has been such a long-term success."

Money didn't hurt either. The Wisconsin Chapter of The Nature Conservancy has been one of the steadfast partners throughout the more than 40 years of preservation efforts. It loaned the first citizens group the money to buy the first parcels. Since then it has acquired most of the remaining prairie, donating much of it to the state and giving some to the University of Wisconsin. "There were hundreds and hundreds of landowners that needed to be contacted and eventually negotiated with," Richter said.

Those efforts resulted in more than 450 lots being acquired and preserved. Only 73 left to go. NOAA's Community-based Restoration Program has given the state more than \$100,000 to manage its portion of the prairie.

The Spanish conquistadors, Gasiorkiewicz notes, used to complain that the tall grass of America's prairies would tickle the belly of their horses. It heartens him to know that there is still a place where a horse can go for a belly tickle.

BURNING THE PRAIRIE

Before the European settlers arrived, the prairies of North America burned regularly. Lightning sparked fires that could burn hundreds of acres. Native Americans put the prairies to the torch to drive game, protect their villages, ease travel and encourage growth of nuts, berries and seeds.

As a result, the plants and animals of the prairies adapted to fire and thrive with it as part of their life cycles. Fire recycles nutrients from the thatch into the soil, so other plants can use them, and direct heating of seeds in soil stimulates germination. In the spring, fire-blackened soil absorbs the sun's heat and warms quickly, which helps plants get an early start. Burning also helps to control shrubs and trees that invade the prairie. Without burning, many of the prairies would eventually turn into forests.

Most prairies have to be burned every three to five years to ensure plant diversity and to control invading species, explained Steve Richter of the Wisconsin Chapter of The Nature Conservancy, which owns and manages a portion of the Chiwaukee Prairie. These so-called "prescribed burns" are less frequent in the Chiwaukee because of the railroad, which runs through the prairie. Sparks created by the wheels rolling along on the tracks frequently ignite fires in the prairie.

"It causes about three wildfires every year somewhere in the prairie," Richter said. "That's usually enough."

SAVING THE CHIWAUKEE

I have planted a garden, so I know what faith is.

I have seen oak trees in the breeze, so I know what grace is.

I have listened to birds singing, so I know what music is.

I have seen mornings without clouds, after showers, so I know what beauty is.

I have seen the miracle of sunset, so I know what grandeur is.

And because I have perceived all these things, I know what wealth is.

—BY PHIL SANDER

WILDFLOWERS PRODUCE A RIOT OF DIFFERENT COLORS IN THE CHIWAUKEE PRAIRIE DEPENDING ON THE SEASON. © Barbara J. Slane, courtesy of the Wisconsin Chapter of The Nature Conservancy

In the gathering dusk of a spring night in 1965, Phil Sander and Al Krampert stood atop the embankment that anchored the railroad line to the shore of Lake Michigan. Spread below them was the last untouched prairie in Wisconsin, maybe the last in the entire Midwest, a vast, treeless expanse that was ablaze in the purple of blooming shooting stars.

"We were struggling with our fears and trying to arrive at an important decision," Krampert remembered five years later in a written memoir. "I was seeking his support and I strongly suspect he was seeking mine. We needed the courage to move in the direction we knew we had to go. We had to make the decision to save Chiwaukee Prairie."

The two had known each other for about a year, drawn together by their love of wild places and of this place in particular. What they didn't know that night by the railroad tracks was that this prairie would keep them bound together for the next 30 years as they would tirelessly lead a coalition of citizens, scientists and conservation groups in a grassroots effort to save it.

Sander, a native of nearby Kenosha in southeastern Wisconsin, had spent his boyhood roaming what was then known as Weyhe Prairie. "In those halcyon days there were no roads or homes along the five-mile stretch of the shore south of Kenosha," Sander wrote in his own memoir of those childhood years

after World War I. “Weyhe Prairie was a mysterious stretch, an isolated land of swells and swales, tall grasses and cattails that reached over our heads. At times we felt as though we were lost in a prairie jungle.”

Krampert grew up on a Midwestern farm during the Depression. Zane Grey’s novels of the old West and Hamlin Garland’s essays on prairie life sparked what would become a lifelong passion for the wildflowers of the fast-disappearing prairies. As an adult, Krampert traveled the West seeking them out.

On one visit to Chiwaukee in 1964, he sought out Sander instead. They touched on many things during that first meeting in Sander’s house – fishing, hunting, traveling, ecology. But mainly they talked about Chiwaukee Prairie.

“Phil,” Krampert asked finally, “is there anything we can do to save it?”

The railroad tracks that the Chicago and Northwestern laid through the prairie had kept early settlers at bay in the 1800s. Back in those days of steam locomotives, firemen on the Chicago-Milwaukee run regularly cleaned their stacks and fireboxes in the prairie. The resulting wildfires deterred anyone with thoughts of building a house in the prairie or even planting crops there.

The giddy exuberance of the 1920s descended on the prairie when investors from Chicago announced various plans to build a model city for the rich, an 18-hole golf course, a hotel and an enclave of sumptuous lakefront houses that they named Chiwaukee on the Lake. An electric railway would connect it all to Chicago, about 50 miles to the south. Though lots were platted and sold, the Depression intervened. A few palatial houses were built along the lake and part of the golf course opened, but most of the plans died with the stock market. About all that’s left of them is a name.

“People think ‘Chiwaukee’ is an Indian word,” explained Eugene C. Gasiorkiewicz. He’s a retired professor at the University of Wisconsin-Parkside in Kenosha and published the first and most complete plant list for the prairie. “It was a marketing ploy,” he went on. “The prairie is halfway between Chicago and Milwaukee. The developers came up with the word in hopes of attracting buyers from those cities. The Indians had nothing to do with it.”

Over the years, other development plans for the prairie also came and went, but an announcement in early 1965 had an ominous ring. Developers said they would build a massive marina for 1,000 boats, a large motel and a golf course in part of the Chiwaukee near the Illinois state line.

That would be the end of the prairie, Hugh Itlis knew. He was a botanist at the time at the University of Wisconsin’s main campus in Madison. “As someone who was very much interested in the flora of Wisconsin, I knew the Chiwaukee was absolutely fabulous,” Itlis, now 84, said. “The marina would have destroyed a very special place, and I wanted to raise a little hell about it.”

He started with the Kenosha county commissioners who had to rezone the prairie to make way for the marina. Itlis and Orie Loucks, another Madison professor, drove two hours in a blinding snowstorm to attend the commissioners’ rezoning hearing in February 1965. Krampert remembered Itlis arriving late and standing before the board with melting snow dripping from his coat.

“You are rezoning land in Pleasant Prairie Township,” Itlis told the commissioners. “Your children will ask, ‘What is a pleasant prairie?’ and you will have no answer – for you will have destroyed it.”

Others also spoke against the rezoning. Most were local people, but some drove 10 miles from Racine or all the way from Milwaukee and Marquette. It did no good. The commissioners rezoned the land.

Meeting in the hallway afterwards, opponents formed an impromptu committee and appointed Krampert to head it. “The women liked him because he was very handsome,” Itlis said. “But he was a good choice. He was a great big guy, oozing

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The Healing of San Francisco Bay Begins

The sluice wheel was turned on July 19, 2004, and one of the most ambitious wetland-restoration projects in the country took its symbolic first step with a rush of briny water into the southern tip of San Francisco Bay. For the first time in more than 40 years, bay waters circulated through stagnant industrial salt ponds to begin the long process of remaking marshes.



THE DISTINCTIVE SCARLET SALT PONDS MAKE CONVENIENT WAYPOINTS FOR ASTRONAUTS, WHO TOOK THIS PHOTOGRAPH FROM SPACE. *Courtesy of the National Aeronautics and Space Administration*

It will probably take three decades to finish the job, but when the project is completed 53 old salt ponds, covering more than 16,000 acres, will be transformed back to tidal marsh or bird nesting habitat, and San Francisco Bay will be a better place.

“I tell people that when we’re done, the bay won’t be like it was before people settled here because there have been too many changes,” says Steve Ritchie of California’s Coastal Conservancy, the project’s manager. “We will have to work with the natural systems that we have, but restoring these lands will lead to vast ecological improvements.”

San Francisco Bay and the Sacramento-San Joaquin delta form the West Coast’s largest estuary, draining about 40 percent of California’s land. With its blend of fresh and ocean waters, thousands of miles of rivers and streams and numerous microclimates and landscapes, the estuary is an ecological treasure that supports an enormous diversity of fish, other animals and plants. About 120 fish species, 255 bird species, 81 mammal species, 30 reptile species and 14 amphibian species live in the estuary. Nearly half the birds of the Pacific Flyway, a critical migratory route, and two-thirds of California’s salmon pass through the estuary.

A century ago, the Bay Area contained almost 200,000 acres of tidal marshes and close to 100,000 acres of seasonal wetlands, creeks and streams. Today, it is surrounded by the fourth-largest metropolitan area in



the country, and 90 percent of the bay's original tidal marshes are gone. They have been drained, filled and converted to farmlands, highways, landfills, industrial complexes, shopping malls, housing developments, commercial salt ponds and airports. Not surprisingly, populations of marsh-dependent fish and wildlife have also dwindled, while water quality has decreased and the risk of flooding has risen.

The non-profit group Save The Bay formed in the 1960s and began pushing for the bay's restoration, noted David Lewis, its executive director. "The regional movement that we started to prevent the bay from being filled in definitely led to general and widespread support for restoration," he said.

Amid much fanfare in 2003, Cargill, Inc. and state and federal agencies announced the final terms of a deal that would turn over ownership of land and mineral rights to 16,500 acres of Cargill salt ponds to the public agencies for \$100 million. Cargill, a multinational food and agricultural products company, was producing at the time about a million tons a year of common salt from the vast array of huge ponds scattered along the bay.

Anyone flying into San Francisco has seen them – large red rectangles clustered along the bay's shore. So distinctive are these scarlet landmarks that astronauts use them as convenient waypoints. The color comes from the microbes and brine shrimp that thrive in the pond's high salinity waters. Every one of those rectangles was once a tidal marsh.

Returning the salt ponds to that state again isn't as simple as merely knocking down the dikes that separate them from the bay, Ritchie explains. For one thing, there are the birds to consider. The bay's natural wet flats

HISTORY OF SALT PRODUCTION IN SAN FRANCISCO BAY



Salt production has a long history in San Francisco Bay, going back to native Ohlone, who dug small ponds to evaporate bay water for salt that they used or traded. Spanish settlers dug larger ponds that they called "salinas," broad, open areas of marsh that captured water during high tides. During the dry, windy summer months, the water would evaporate and the salt would be harvested.

This picture depicts the ponds in the mid-19th century. By the end of that century, the relatively small and scattered ponds were subdivided and expanded in scale from 20 acres to 1,000 acres. Within 100 years, this native industry would grow into one of the largest solar evaporation industries in the world. That development resulted in the greatest transformation of the bay's landscape.

Credit: From New Historical Atlas of Alameda County, Thompson and West, 1878. Reprinted with permission of Bay Nature magazine, Oct-Dec. 2004



TOP LEFT: AFTER BAY WATER EVAPORATES, INHOSPITABLE, BARREN SALT FLATS ARE LEFT BEHIND. MIDDLE: AFTER RESTORATION, THOSE BARREN FLATS BECOME WETLANDS AGAIN. ABOVE RIGHT: A DREDGE BEGINS THE WORK OF RESTORING A SALT POND. *All photos courtesy of the California Coastal Conservancy*

disappeared long ago, and birds that need such habitat have come to rely on the artificial salt ponds as substitutes. The ponds provide critical foraging habitat and shelter for at least 20 migratory bird species, but western sandpipers are particularly dependent on them. In spring, their numbers on the ponds can swell to 700,000—a significant percentage of the population on the Pacific Flyway.

Western snowy plovers, an endangered species, breed on the barren islands of salt that form after the water evaporates. "To us those places look like moonscapes," Ritchie says, "but the snowy plovers think they're quite cool. They can see any predators coming."

The restoration also has to provide public access and ensure that the densely populated communities that ring the bay aren't flooded by storms and high tides after the levees encircling the ponds come down. "We can't flood Silicon Valley," Ritchie said. "That wouldn't be good."

All those issues were worked out during an extensive planning process, and the rest of the work on what's formally known as the South Bay Salt Pond Restoration Project was to begin in 2009 through early 2010 with three major restorations, totaling more than 2,200 acres. California's severe budget shortfall almost brought it all to a halt, though, but Ritchie found other sources of money – including \$5.8 million from a NOAA stimulus grant – to keep the project on track.

NOAA has contracted with Save The Bay, to restore crucial transition zone habitat at the edge of several ponds. "The low marsh will take care of itself. It's really not necessary to do any planting," Lewis said. "Our community-based restoration is focused on restoring critical habitat in the high marsh and levees that have been overgrown with weeds and exotic plants."

The group works with landowners to develop a restoration plan and to re-establish native plants. It grows the plants from seeds collected locally and volunteers plant the seedlings.

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OYSTER REEFS: Water Filters and Baby Nurseries

America's native oysters are excellent ecosystem engineers. The homes that they build in the shallows of our estuaries help keep the water clean, protect the shoreline from damaging waves and attract a wide array of other marine creatures that come to the oysters' home to eat, reproduce or to find shelter from predators.

These large congregations of oysters are known by various names – beds, bars, banks, reefs, rocks, hard bottom. By any name, they are among the most productive fish habitat along our coastal shoreline.

THE BENEFITS

The Eastern oyster (*Crassostrea virginica*), native to the Atlantic and Gulf coasts, is the best-known builder of massive reefs. Successive generations of oysters live atop the dead shells of their descendents. Over time, scientists estimate the mass of oysters can approach as many as 6,000, or about 45 bushels, within a single square yard of a healthy reef.

Combine a cafeteria buffet, a hospital nursery and a water filtration plant and you come close to what that reef means to the estuary. All those oysters form dense layers of shells that rise from the soft mud around it. This island is filled with nooks, crannies and crevices that are inhabited by organisms great and small. Just how many species use an oyster reef depends on its location and the water's temperature, depth and salinity. Scientists in North Carolina have documented more than 300 species of invertebrates and more than 40 species of fish and crustaceans on reefs there. Shrimp and small fish like gobies, blennies and toadfish feed on the algae, bacteria, fungi and worms that colonize the oyster reefs.

Others need the reefs to successfully spawn. Toadfish, for instance, attach their eggs to the underside of oyster shells, while gobies, blennies, and skilfish place their eggs in the shells of recently dead oysters.

The small fish and crustaceans, of course, attract larger species in search of a meal. Red and black drum, bluefish, spot, Atlantic croaker, weakfish, spotted seatrout, summer and southern flounder and blue crab are just a few of the important species that feed at the reefs.

Newly hatched sheepshead, gag, snappers, shrimp, and stone and blue crabs find shelter among the shells, which are considered important nursery habitat for numerous species.

The oysters themselves play a vital role as the estuary's natural filter. By removing organic material and nutrients from the water, the oysters help keep the water clear and free from algae, which in turn aids the underwater grass beds.

Reefs also stabilize stream banks and decrease erosion. Large areas of oyster shells can block waves and reduce erosion and turbidity.

THE TRENDS

America's oysters were once a worldwide delicacy. They came first from the Northeast, from places like Bivalve on the Maurice River in southern New Jersey. By 1890, more than 90 railroad cars full of Delaware River oysters were leaving the little town each week. Catches steadily dropped throughout the region and nearly ceased in the 1950s after disease wiped out many of the remaining oysters. The oysters have never fully recovered.

But by then, the industry had moved south. In the late 1800s, annual oyster harvests in the Southeast routinely topped 10 million pounds a year, and peaked in 1908 when the harvest was nearly 20 million pounds. Since then, though, the oyster populations have collapsed under the weight of disease, pollution and overfishing. The commercial harvest fell throughout the 20th century and is now at historic lows. Today, yearly harvests in the Southeast average about three million pounds. Before the 1950s, Chesapeake Bay accounted for almost half the catch of the Eastern oyster; today it yields only about 2 percent.



OYSTERS BUILD UPON THE SHELLS OF OTHERS. Photo courtesy of the N.C. Division of Marine Fisheries.

Though they have fluctuated over the years, oyster harvests along the Gulf Coast haven't shown a similar collapse. The Gulf States are now the leading producers of Eastern oysters.

On the west coast, overfishing and pollution have all but wiped out the native Olympia oyster (*Ostrea conchaphila* or *Ostrea lurida*).

THE THREATS

Fishing for oysters with towed dredges is the greatest physical threat to oyster reefs. Studies have shown that using dredges for one season can reduce the height of an oyster reef by 30 percent. Trawling for shrimp, crabs and clams and dredging channels can do similar, but less dramatic, damage to the reefs.

Water pollution and diseases are more widespread threats. Sediment washed off the land during storms can bury oyster shells. Without the shell on the bottom, oyster larvae can't attach themselves, or "set." Excessive sedimentation can also harm shellfish by clogging their gills. Sediment was the largest cause of water-quality degradation in the Albemarle-Pamlico estuary. Excessive nutrients, such as phosphorus and nitrogen, can also lead to layers of water so devoid of oxygen that oysters, which are unable to move to better water, suffocate. Polluted stormwater runoff can contaminate the shallow water where oysters grow with high levels of bacteria that the oysters ingest and then become unsafe to eat.

Profile of the Amazing Oyster

They aren't the prettiest things in the water, but oysters have long been one of the most important – ecologically and gastronomically – on both sides of the Atlantic.

When they arrived on the shores of North America, the first white settlers were most impressed with the abundance, size and succulence of oysters, whose thick rafts of reefs were hazards to unwary navigators in their small wooden boats. Friendly Indians reportedly brought oysters along with wild turkeys to the first Thanksgiving. They taught these strangers how to hunt for the fat shellfish with leather tongs and how to dry them for winter food. Settlers on the other side of the continent found large mounds of oyster shells scattered about what they would come to call San Francisco Bay, attesting to the natives' affinity for the shellfish.

Across the Atlantic, oysters had been a prized food since the pre-Christian era. The ancient Romans served large quantities at their banquets, learned to cultivate them and even made a monetary unit, the *denarius*, equal in value to one oyster.

Quite an illustrious history for a critter that doesn't even have a backbone. In fact, oysters are scientifically classed as *mollusks*, a word from the Latin meaning "soft." Protecting those soft bodies is a hard shell made up of two valves that are joined by a hinge and held together by a strong muscle. Except in the earliest stage of their development, oysters even lack the power of locomotion. They spend much of their lives lying still on the floor of brackish bays, coves and estuaries, usually attached to rocks, other oysters or some other hard, submerged object, sometimes in great clusters.

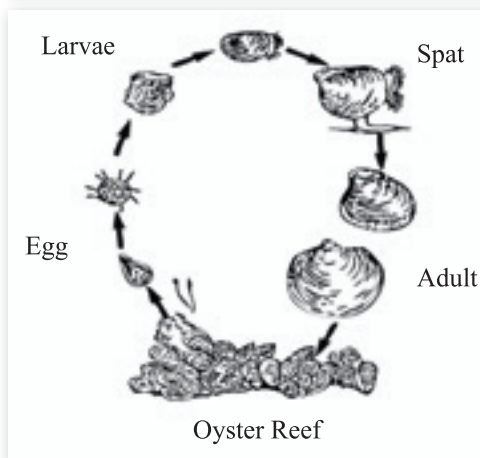
Many different species of oysters live in the inshore waters of the world's temperate and tropical seas. The one native to the Atlantic and Gulf coasts, *Crassostrea virginica*, is commonly known as the American oyster, the Atlantic oyster and the Eastern oyster. It is a hardy species that can live in waters as varied in salinity and temperature as those found from Nova Scotia to the Gulf of Mexico.

The Olympia oyster, *Ostrea conchaphila*, that the Native Americans of our Pacific coast so loved were all but wiped out by overharvesting and pollution and are now the subject of an active restoration effort that NOAA is helping fund. Most of the oysters commercially harvested on the West Coast were introduced from Japan.

THE SEXY OYSTER

The separate sexes of the American oyster ripen in early summer. When the water warms to about 68 degrees, they release eggs and sperm into the water. During the spawning season, a single female, by clapping her shells gently, will puff out many millions of buoyant eggs, and a male will release an even greater number of sperm. The fertilized egg develops into a microscopic larva, which swims and drifts in the tidal currents for about three weeks. The larva may travel far from the spawning area, feeding on microscopic plants and, in turn, being eaten by other animals. Less than one percent of the young larvae reach the next stage of development.

When it's about the size of a grain of pepper, each larva extends a probing foot and seeks a permanent place to live. Once it finds a suitable clean, hard surface, the foot gland ejects a tiny pool of cement-like adhesive. The little oyster then turns on its left side, cements itself to the object, and remains immobile for the rest of its life. From then on,



TOP: YOUNG OYSTERS, CALLED SPAT, SET ON A CLAM SHELL. Courtesy of Bill Shadel, American Littoral Society
LEFT: LIFECYCLE OF THE OYSTER

it can feed only on what food the water brings and is unable to escape overcrowding, pollution or its enemies.

The small oyster, or *spat*, now the size of a dime, grows by pumping water through its body and filtering out its food – mostly algae and decaying plant material. In this way it cleans the waters. A healthy three-inch-long oyster can filter approximately 50 gallons of water a day. Oysters provide other ecological benefits as well. Oyster reefs, with their many folds and crevasses, can have fifty times the surface area of a similarly extensive flat bottom. Its convolutions provide habitat for an enormous range of other animals, such as worms, snails, sea squirts, sponges, small crabs and numerous species of fishes.

STORMWATER AND SHELLFISH

Rain washing off streets, driveways, parking lots and other constructed surfaces carries with it a witch's brew of pollutants, including bacteria, which can have a devastating effect on shellfish beds.

This "stormwater runoff" is now the largest source of water pollution in most of our coastal watersheds, accounting for as much as 80 percent of the pollution in our estuaries and ocean. Runoff contaminated with bacteria is responsible for closing hundreds of thousands of acres of oyster and clam beds to harvesting.

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GROWING OYSTERS IN THE SHADOW OF SKYSCRAPERS

Ben Longstreth had a crazy notion back in 1997. What if oysters could grow again in the waters surrounding New York City? What would that say about restoring one of the most polluted coastal environments in the world?

It had been more than 70 years since anyone thought about bringing oysters back to what had once been prime bivalve real estate. When Henry Hudson came this way in 1609, oyster reefs covered 350 square miles of the bay's bottom, from Sandy Hook in New Jersey north to Ossining on the river that now bears Hudson's name. Oysters grew abundantly in the Navesink and Shrewsbury rivers, the Arthur Kill and Newark Bay. Up until 1900, New York oysters were in high demand the world over and supported an extensive commercial fishery.

But overfishing, siltation and severe pollution drove the oysters virtually extinct during the next two decades. New York state banned all oystering in the waters around the city in 1924, and the once-thriving oyster business died. The great oyster reefs that filtered the water were gone. The biological diversity of the estuary declined dramatically, and the bay bottom got muddier and its depths murkier.

Longstreth, who had just joined the American Littoral Society's N.Y./N.J. Baykeeper® program in 1997, recruited some volunteers that year and took the first steps in the long journey to bring the oysters back. They put out small bags of oysters at 15 places around New York. To everyone's surprise and delight, oysters grew well at all but one site.

In a dramatic second step in 1999, the Baykeeper program created a new artificial oyster reef at Liberty Island, known historically as Oyster Island. It was the first reef built in the bay since the 19th century. "That was an incredible moment," Longstreth remembered in 2006. "It was a great symbol of our dramatic progress in cleaning up the bay, and of our total commitment to a full restoration of estuary habitat."

The new reef generated publicity and provided needed marine habitat. Red beard sponges, blue crab and other invertebrates took to the reef, but very few indigenous oysters. There just weren't enough oysters left to produce drifting larvae that could colonize the reef.

Relying on nature to do the job would take decades. Longstreth and the Baykeeper program decided in 2000 to lend a hand. They recruited volunteers from around the region to grow oysters in waters near their homes or at public sites. These "oyster gardeners" grew about 10,000 oysters at 25 sites that first year and successfully produced spawning oysters to plant on two restored oyster reefs in the estuary.

Michael Stringer, who managed the Baykeeper's oyster program from 2000 to 2003, remembered those early days. "I would go around the estuary and talk to folks who just looked at me incredulously," he said in 2006. "The environmental professionals, agency people and research scientists mostly thought we were out in left field. They thought oyster beds were from a bygone era and lost to the estuary forever."

The Baykeeper did find enthusiastic allies. Its oyster program has received ongoing funding and support from the American Littoral Society through the NOAA-RAE partnership and the Hudson River Foundation. It also got significant scientific support from NOAA's National Marine Fisheries Service and approval from the N.J. Department of Environmental Protection and the U.S. Army Corps of Engineers to build an oyster reef in New Jersey waters.

Meredith Comi, who currently heads the program for the now-independent

Baykeeper® organization, doesn't get as many quizzical stares anymore, but the challenges of growing oysters in severely polluted water haven't diminished. She now has about 600 active gardeners, who grow oysters at about 70 sites around New York. Comi figures that they have placed upwards of 300,000 oysters on the two reefs that the Baykeeper group maintains in the estuary.

The oysters, though, aren't reproducing naturally in any numbers yet to ensure their continued survival. So young oysters, or "spat," have to be imported from Maryland. The spat are circulated in large tanks that contain mesh bags of oyster or clam shells. After the spat attach to the shells, the bags are given to the gardeners, who tend them for a year in local waters. Comi then collects the bags and places them on reefs.

"I'm always amazed when I go to conferences at how easy it is in other places," she says. "We have an estuary that is pretty much devoid of oysters that are producing larvae. We have to set the oyster larvae. It's time consuming and labor intensive."

Judging success under those circumstances has been a moving target, Comi said. Just knowing that oysters will survive in these waters marked a step forward.



STUDENTS FROM BAYONNE HIGH SCHOOL IN NEW JERSEY BEGIN TO SET THE CAGES THAT WILL BE USED TO GROW OYSTERS IN NEWARK BAY. *Courtesy of the N.Y./N.J. Baykeeper®*

That they will grow was another sign of progress. Now there are indications that they are naturally reproducing on at least one reef.

Similar programs pin their ultimate success on the re-opening of polluted shellfish waters. That's not likely to happen anytime soon around New York, so Comi's final measurement is broader and less defined.

"We have educated thousands of people about oysters and the pollution of the estuary," she said. "The watermen and baymen want to see this work. They are our biggest advocates. Our gardeners also become big advocates for controlling pollution. Those are all measures of our success."



History and Science Through Oysters

In southern New Jersey, along the shores of Delaware Bay, there are dozens of reminders of the region's long connection to the Eastern oyster: Old boat-building sheds that once turned out the sturdy schooners that plied the bay's waters for oysters, remnants of shucking houses and packing plants, towns with names like Shellpile and Bivalve. Talk to the old-timers and they will tell you about the work songs chanted around the shucking tables, about the boxcars heading north packed with oysters, about oyster stews hearty enough to ward off the cold of the darkest December night.

They are all part of a rich history when the oyster was king. Sadly, it is a story unknown to most of the children who attend the area's schools. Lisa Calvo is trying to change all that.

Calvo had an idea in 2006. At the time she was a researcher at Rutgers University's Haskins Shellfish Research Laboratory in southern Jersey. The oyster, she thought, could be a way to reach out to kids and teach them about a healthy Delaware Bay and about the importance of restoring its habitat. It also could put them in touch with their history

and culture.

"I have always been interested in science education," she said. "I love research but I felt a connection to education. I just thought it was a good opportunity to do some education."

With federal funding, including some NOAA money through Restore America's Estuaries via the American Littoral Society, Calvo took her Project PORTS (Promoting Oyster Restoration Through Schools) to 10 schools in 2007. She has added four more since.

She goes mainly to elementary and middle schools, offering pupils and their teachers a wide variety of activities that cross curricula and grade levels. She works with individual teachers and their classes or with entire schools. "For kindergartners, it may just be a touch tank," Calvo explains. "Older children get to hold oysters and examine them on the inside and outside and learn about invertebrates."

Her curriculum guide allows teachers to use the oyster as a vehicle to teach basic math and science concepts and history and language arts. By incorporating science with local history, pupils can better appreciate and understand the complexity of an important local environmental problem—the decline of the Eastern oyster.

After the kids have learned that lesson, Calvo puts them to work filling mesh bags with recycled shells. She then moves the bags to the Haskins Lab where they are placed in the bay to attract baby oysters, called spat. Getting students directly involved in an oyster-habitat restoration project greatly enriches the educational value of the classroom



lessons, she said. “I have to grab the kids off the shell pile so the next group can bag,” Calvo said. “It’s hands on, it’s dirty and it smells a little bit. The kids love it.”

Calvo, who now works as the watershed coordinator for the Jacques Cousteau National Estuarine Research Reserve in Bridgeton, figures in this way she has reached more than 1,500 kids in two years. Those children have filled more than 3,500 bags of shells, which then attracted more than four million oyster spat. Some of those spat survived and are now growing on a sanctuary reef in the bay. The kids also know how Bivalve got its name.

“This has been a very rewarding experience,” Calvo says.

FAR LEFT: FOURTH-GRADE STUDENTS AT FRIENDS SCHOOL MULICA HILL IN MULICA HILL, N.J., PARTICIPATE IN PROJECT PORTS’ “THAT’S GROSS ANATOMY, THE INS AND OUTS OF OYSTERS” SCIENCE ACTIVITY. LEFT: JEFF SJOGREN, PROJECT PORTS VOLUNTEER, EMPTIES THE SHELL BAGS CONTAINING OYSTER SPAT AT THE CONSERVATION AREA IN DELAWARE BAY. ABOVE: STUDENTS FROM WEST AVENUE ELEMENTARY SCHOOL IN BRIDGETON, N.J., BUILD SHELL BAGS AT THEIR SCHOOL FOR PROJECT PORTS. ABOVE RIGHT: FOURTH-GRADE STUDENTS IN CUMBERLAND COUNTY, N.J., CREATE SIGNATURE OYSTER SHELLS FOR PROJECT PORTS. THE MESSAGES ARE OFTEN DIRECTED TOWARD THE OYSTERS THEY HOPE TO HELP. THE SHELLS ARE LATER PLACED IN MESH BAGS AND USED ON OYSTER REEFS IN DELAWARE BAY. *All photos courtesy of Project PORTS*

“ARSTERS” HE-STEW

- Mess of bacon
- 8 Large onions
- 2 Hefty stalks of celery
- 48 Oysters
- Oyster liquor
- Tapioca powder
- Milk
- Saffron
- 1/2 lb. butter

From James A. Michener’s *Chesapeake* 1978, Random House, Inc., Chapter 22, “The Waterman.”

An excerpted conversation between the cook, Big Jimbo, and the crew aboard the Skipjack Jessie T. as she prepared for her maiden trip to dredge for “arsters” in Maryland’s Choptank River.

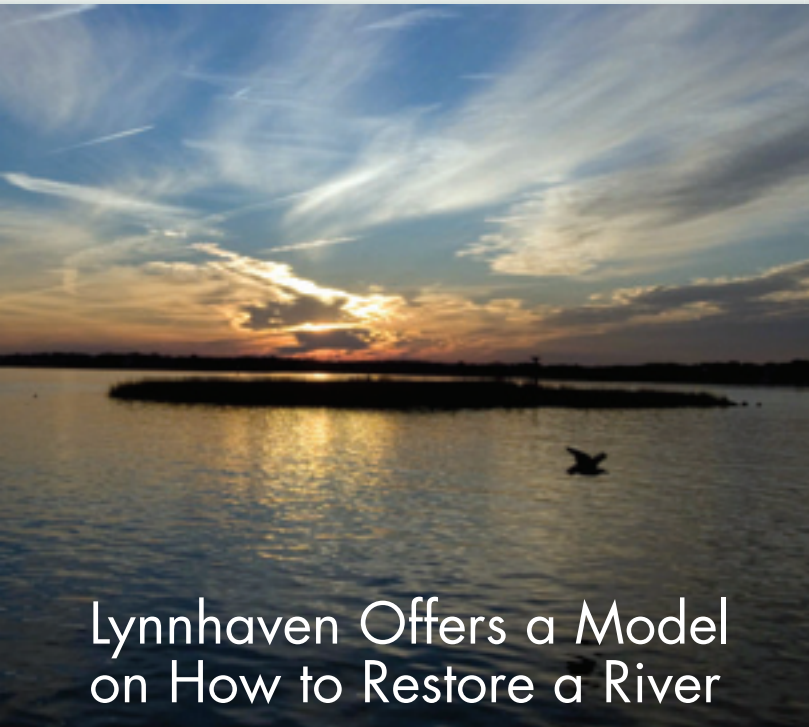
A She-stew is the traditional one: Eight oysters per person boiled slightly in their own liquor, then in milk thickened with flour, flavored with celery, salt and pepper. A great opening course, but not a meal for a working man.

A He-Stew is quite different, as Big Jimbo prepared his version. First he took

a mess a bacon and fried it crisp. As it sizzled, he chopped eight large onions and two hefty stalks of celery. Deftly he whisked the bacon out, tossing the vegetables into the hot oil to saute. Soon he withdrew them, placing them with the bacon. Then he tossed the forty eight oysters into the pan, browning them just enough to implant the flavor, then he quickly poured in the liquor from the oysters and allowed them to cook until their gills wrinkled.

Next Big Jimbo did two things that made his stew unforgettable. Taking a small pinch of tapioca powder, he tossed it into the oysters and liquor and in a few minutes the finely ground tapioca powder had expanded it into a large translucent, gelatinous mass. When he was satisfied he poured the oysters into the milk, which he had already brought to a simmer, tossed in the vegetables, then crumbled the bacon between his fingers, throwing it on top.

The sturdy dish was almost ready. Finally, Big Jimbo dusted the top of the stew with Saffron, giving it a golden richness, which he augmented with a hollowly of butter at the last moment. When the crew dug in, they found one of the richest, tastiest “Arster” stews a marine cook had ever devised.



Lynnhaven Offers a Model on How to Restore a River

Hap Chalmers proudly pulled from his pocket a sheet of paper with the names of all the restaurants that have bought oysters from his son Cam, who has an aquaculture business on the Lynnhaven River in Virginia Beach, Va. It was an impressive list. On it were the names of restaurants in Philadelphia, Baltimore, Las Vegas, New York, even San Francisco. More impressive was the fact that anyone at all was buying Chalmers' Lynnhaven oysters.

Just a few years ago, the river was so contaminated by bacteria that almost all of its oyster beds were off-limits to shellfishing. What few oysters grew in the river were unsafe to eat and illegal to sell.

"We're back!" Hap told a newspaper reporter in late 2008 after showing off his list, a broad smile spreading across his face.

The Lynnhaven seems to have made at least a partial comeback after decades of abuse. Almost a third of its oyster beds have recently been reopened for harvesting – a sign of improving water quality – and Lynnhaven oysters are once again on local restaurant menus – a financial boon to local watermen.

To get this far, the river needed a great deal of help from a great many people. City officials had to commit themselves to stanching the flow of stormwater that was poisoning the Lynnhaven with bacteria. State and federal agencies had to rebuild the river's oyster beds that had been covered by sediment. Non-profit groups had to advocate tirelessly on its behalf and teach people about the river's problems, and those who live along the river had to roll up their sleeves and volunteer to join committees, attend meetings, grow seed oysters for the new reefs, pick up after their pets and generally think about the river in a new way. The combined efforts could serve as a model for how to resuscitate a comatose river, said Tommy Leggett of the Chesapeake Bay Foundation.

"It was a combination of everybody doing something," noted Leggett, a former commercial fisherman who is now the foundation's oyster resto-

LEFT: SUNSET ON THE LYNNHAVEN RIVER. *Courtesy of Lynnhaven River Now*
RIGHT: OSPREYS GUARD THEIR NEST ON THE LYNNHAVEN RIVER. *Courtesy of Lynnhaven River Now*

ration and fisheries scientist in Virginia. "A whole lot of different folks contributed towards the success we've seen on the Lynnhaven."

The river was once highly prized for its oysters, but unchecked and largely unregulated development in the 1960s and '70s gradually took its toll. The Lynnhaven's watershed covers 64 square miles of Virginia Beach. Within it live almost 250,000 people, or roughly half of the city's population. At least 35 percent of the watershed has been covered with roads, parking lots, rooftops and other hard surfaces, which increased runoff after every rain. More than 1,000 pipes direct that untreated stormwater to the river, which became laden with sediment and overloaded with nutrients, toxins and bacteria.

"It's basically an urban river and its watershed has been totally developed," explained Karen Forget, executive director of the advocacy group Lynnhaven River Now. "It's been a major challenge because most development took place when there were virtually no limitations on development or controls on stormwater."

By 2002, 98 percent of the river's oyster beds were closed to shellfishing because of high bacteria levels and it seemed the Lynnhaven was destined to go the way of other polluted urban rivers. But that was the year Harry Lester, Andy Fine and Bob Stanton decided to do something about it. The three businessmen got together with other prominent city leaders to form what became Lynnhaven River Now. Their goal was simple: Bring back the oysters. "We were all novices at this," Lester recalls. "We had no idea what it would take or how long it would take. We only knew that the river needed help."

The group's members did have the ear of the city council, remembers Bob Johnston, Virginia Beach's permit administrator. "The council members realized how important it was to clean up the river," he said.

Things began to happen. The council, in 2003, declared restoration of the Lynnhaven River to be a high priority, and the city set out to reduce

pollutants entering the river. The Department of Public Utilities, for instance, completed more than 40 projects, costing almost \$46 million, to extend, repair or rehabilitate the public sewer system in the watershed. The city spent more than \$6 million on other environmental projects, ranging from installing solar powered aerators to boost oxygen levels in lakes draining into the river and building wetlands to treat stormwater to bacterial monitoring and modeling.

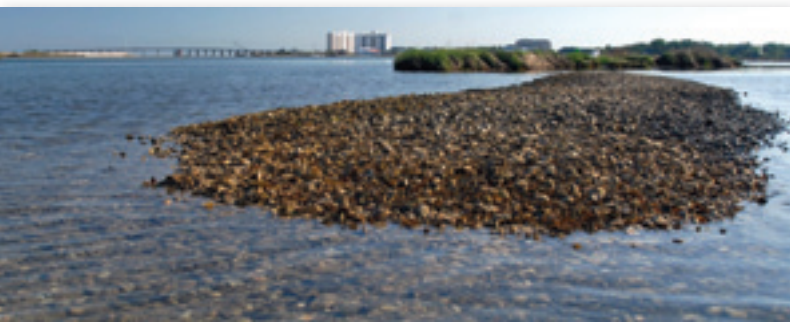
The city now has a task force made up of section heads that meets monthly to discuss water-quality issues, noted Clay Bernick, Virginia Beach's administrator for environmental management. "It's gotten everybody on the same page, and we're moving in the same direction," he said. "We're seeing far less fall through the cracks."

Plans to manage stormwater in each of the 33 watersheds in the city are being devised, and the city is beginning to implement the recommendations of a Green Ribbon Commission that looked at city ordinances, codes and procedures to make them more environmentally friendly. It also gave Army Corps of Engineers half of the cost of a \$3 million study to restore the Lynnhaven. The study is looking at ways to rebuild wetlands and essential fish habitats and re-establish underwater grass beds.

"I think the city deserves a pat on the back," said Christy Everett, the Chesapeake Bay Foundation's assistant director in Virginia. "They've put amazing resources toward this. They're doing much more than any other city."

The Corps of Engineers' Norfolk District also played a role. It built almost 60 acres of oysters reefs in the river that are now sanctuaries where harvesting is prohibited. Along with the Virginia Institute of Marine Science and the state's Marine Resources Commission, the corps has also built more than 100 acres of artificial oyster reefs and seeded them with disease-resistant oysters.

Leggett estimates that the Chesapeake Bay Foundation probably planted 2-3 million oysters in the Lynnhaven. Many were supplied by volunteers in the foundation's program that helps people grow oysters under their docks. Those oysters are then used in restoration projects.



A REEF IS EXPOSED DURING LOW TIDE ON THE LYNNHAVEN RIVER. *Courtesy of Lynnhaven River Now*

Most people, though, give much of the credit for the river's rebounding fortunes to Lynnhaven River Now. Its educational programs teach people about the problems facing the river and how their actions affect the Lynnhaven. It has partnered with the city on a range of activities, from producing television ads to upgrading sewer systems. Its advocacy has led to a ban on discharges from marine toilets into the Lynnhaven and more effective controls on stormwater. "Lynnhaven River Now has just been a fantastic partner," Johnston said. "I wish I had one of those organizations in every watershed in the city."

Everybody's work seems to be paying off. About seven percent of the

river's oyster beds were open to harvesting by 2006. More than 1,400 acres were opened the following year and another 112 acres were added in 2008. Harvesting is now allowed in about 31 percent of the Lynnhaven.

Whether these gains are long-term may be debatable. Some argue that the falling bacteria levels are due to abnormally low rainfall and the resulting decreased runoff, which carries the bacteria to the river. Everett's not one of them. The Lynnhaven has turned a corner, she thinks. But even if some of the reopened oyster beds have to eventually be closed again, the work everyone has done has already paid dividends, she says.

"Now there are signs of hope," Everett said. "You can now eat Lynnhaven oysters. You've got to give people some hope. While everything's not perfect, it shows that you can slow the pace of deterioration and that you can begin to turn things around."

BRINGING BACK THE OYSTER: A 'QUIET JOY'

As a junior officer in the Navy stationed in Norfolk, Va., in the early 1970s, Harry Lester and his buddies often ate at The Duck, a little oyster place on the Lynnhaven River in nearby Virginia Beach.

"You used to tell them how many oysters you wanted and they'd have people there shuck them for you. It was such a really wonderful experience and was one of those lasting memories," Lester, 63, recalls. "Then in my adult lifetime it went away. The oysters they were shucking and I was eating just disappeared. Life changed."

Lester settled in Virginia Beach after the Navy. The Duck was torn down; the river that supplied its oysters slowly succumbed as a booming city grew around it, its oyster beds covered by silt or shut down by bacteria from contaminated runoff and sewage discharges.

"I was part of the problem," says Lester, a commercial real-estate broker for 30 years. "You could say that I was paying for past sins."

So Harry Lester felt an obligation to do something. He and Andy Fine, a lawyer who also developed real estate, called about 20 of their friends in 2002 to talk about what they could do to help the Lynnhaven. "We picked the oyster as a metaphor for clean water, not having any idea that bringing them back was the hardest thing to do," he said.

The group was made up of mostly business people and well-known community leaders. Few had resumes of the typical environmental advocate. They did have connections at City Hall and cordial relationships with those who served on Virginia Beach's city council.

"We were the catalyst," says Lester, now the president of Eastern Virginia Medical School. "We had a nice group of names and a little bit of money and we were friendly with the city council. We urged the city to do its part to help restore oysters in the river. And the city responded. Clean water is a hard thing to be against."

The committee became what is now Lynnhaven River Now, a non-profit group with more than 3,000 members that is widely credited for leading the effort to revive the river. Its programs focus on identifying and reducing pollutants, restoring vital habitat, raising awareness and engaging the public. Its partners include such diverse groups as the town of Virginia Beach, the Army Corps of Engineers, the Chesapeake Bay Foundation, the Virginia Institute of Marine Science and the Virginia Marine Resources Commission.

The Virginia General Assembly passed a resolution in 2009 commending Lester and Fine for their work on the Lynnhaven. One suspects that seeing the group he helped found bring back the oysters of his youth is recognition enough for Lester.

"It's one of the quiet joys of my life," he says.

SUBMERGED AQUATIC VEGETATION:

Underwater Gardens Nurture Young of Many Species

They clean the water, provide a haven for young fish and are food for scores of different birds and sea creatures. These small flowering plants, known to scientists by the utilitarian moniker “SAV” for submerged aquatic vegetation, grow mostly unseen beneath the water and help keep our coastal estuaries healthy.

THE BENEFITS

This underwater garden is an important part of the estuary's ecosystem. The plants are top-notch recyclers, for instance. They take nutrients such as phosphorus and



nitrogen from the sediment and release them into the water when they die.

Within seagrass communities, a single acre of grass can produce more than 10 tons of leaves a year. This vast biomass provides food, habitat and nursery areas for a myriad of adult and juvenile vertebrates and invertebrates. A single acre of seagrass may support as many as 40,000 fish and 50 million small invertebrates. Because seagrasses support such high biodiversity, and because of their sensitivity to changes in water quality, they are important indicators of the overall health of coastal ecosystems.

More than 40 different species of fish and invertebrates have been collected from grass beds, which are busy nurseries for the young of many marine species including striped bass, red drum, salmon, flounder, blue crabs and pink shrimp. Grass shrimp, spotted seatrout and weakfish spawn in the grass, and the Atlantic bay scallop needs grass meadows to survive. The grasses are also important food sources for many types of birds.

PROFILE OF COMMON UNDERWATER GRASSES

About 60 species of seagrasses grow in coastal waters worldwide. Here's a look at four that are commonly found in U.S. coastal waters.

EEL GRASS (*Zostera marina*)

U.S. coastal distribution: Maine to North Carolina, Washington to California. **Habitat:** Found in sheltered bays, salt ponds, inlets, tidal flats and creeks and at the mouth of estuaries. It prefers shallow, high-saline waters and sandy mud. **Description:** Slender, ribbon-like leaves with rounded leaf tips that grow along joints of the stem. **Ecological significance:** Important habitat for numerous marine species, including blue crabs, Dungeness crabs, spider crabs, scallops, juvenile salmon, seahorses, pipefish and speckled trout. It is also an important food source for Brant geese.

SAGO PONDWEED (*Potamogeton pectinatus*)

U.S. coastal distribution: Widespread along the Atlantic, Gulf and Pacific coasts and along the Great Lakes. **Habitat:** Generally found in fresh to moderately brackish water and prefers silty or muddy sediments. It tolerates strong currents and wave action better than most other underwater grasses because of its long roots and rhizomes. It can also grow in polluted water. **Description:** Long, narrow, thread-like leaves that taper to a point. Branched stems create bushy clusters that fan out and float on the surface. Sheath at the leaf is pointed like a bayonet, and the clustered flowers look like beads. **Ecological significance:** Considered one of the most valuable food sources for waterfowl in North America. Its highly nutritious seeds, tubers, leaves, stems and roots are consumed by numerous species of ducks, geese, swans and marsh and shorebirds.

SHOAL GRASS (*Halodule wrightii*)

U.S. coastal distribution: North Carolina south through the Gulf of Mexico, California coast. **Habitat:** As the name implies, it grows in shallow water, close to shore where other grasses can't grow. It's a relatively fast-growing species that colonizes barren sandy areas in quiet waters. **Description:** Ribbon-like flat leaves that, exposed at low tide, look like grass in a lawn. **Ecological significance:** Because it is hardy and fast-growing, the grass is useful in restoring areas damaged by erosion.

Transplants of shoal grass colonize the damaged areas relatively quickly, preventing further erosion and allowing for the establishment of other species of seagrass and marine life.

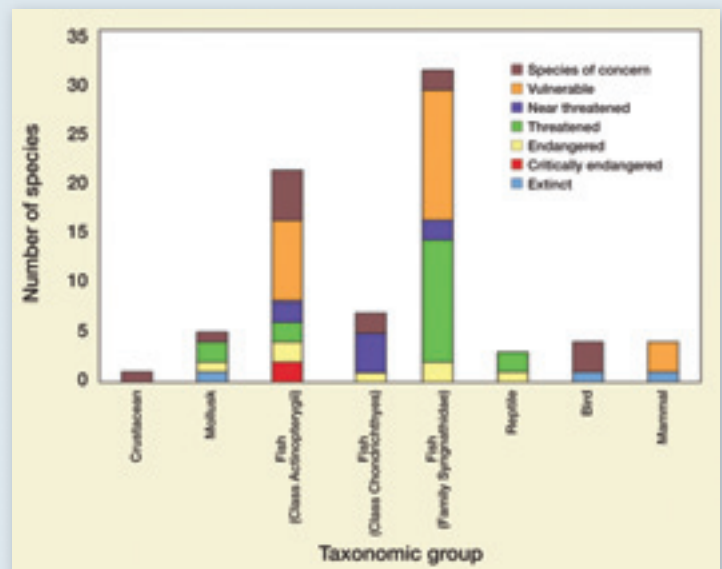
TURTLE GRASS (*Thalassia testudinum*)

U.S. coastal distribution: Central Florida south to the Gulf of Mexico. **Habitat:**

Requires high salinity water sheltered from extreme wave action. It reaches depths of 60 feet in clear water and can stand brief exposure to air at low tide.

Description: Erect, green leaves that arise in clusters from short stalk. They are finely veined and rounded at the tips. The flowers are large, greenish white to pale pink and produce prominent seed pods that often wash ashore. It grows in large mats throughout its range. **Ecological significance:** The common name of this plant refers to green sea turtles that graze on large fields of this seagrass. Many fish also feed on the plant.

SPECIES OF CONCERN ASSOCIATED WITH SEAGRASSES



Hughes, A. et al. Associations of concern: declining seagrasses and threatened dependent species. 2009. *Front Ecol Environ* 2009; 7(5): 242–246, doi:10.1890/080041 (published online 10 Oct 2008)



FAR LEFT: DIVERS GO THROUGH THE SLOW PROCESS OF HAND PLANTING EELGRASS. *Courtesy of Save The (Narragansett) Bay* **ABOVE:** A HEALTHY SEAGRASS BED LIKE THIS ONE PROVIDES FOOD AND SHELTER FOR MANY FISH AND OTHER CREATURES. © NOAA, Heather Dine

Plant beds also tend to reduce shoreline erosion by sheltering the land from waves. And they help cleanse the water, with their leaves acting as screens to remove sediment.

THE TRENDS

Though they are an invaluable part of our marine environment, seagrasses are disappearing at an alarming rate. Scientists, in a study published in June 2009*, found that 58 percent of the seagrass meadows around the world are in decline. Some of the losses in U.S. waters are staggering: Galveston Bay in Texas, the seventh-largest estuary in the country, has lost 89 percent of its grass beds since 1956. Mobile Bay in Alabama, which was designated as a National Estuary by the U.S. Environmental Protection Agency, has lost 82 percent of its grasses since 1981. Tampa Bay in Florida lost 63 percent since 1879. More than a third of the grasses have disappeared in the East River in New York since 1937 and more than a quarter in Nantucket Harbor since 1994.

The researchers also found that about 30 percent of the world's seagrasses have disappeared over the last three decades and that since 1990 the annual rate of loss worldwide has increased from four to seven percent a year.

Dr. William Dennison of the University of Maryland's Center for Environmental Science and the report's co-author offered a sobering analogy when the report was released "Globally, we lose a seagrass meadow the size of a soccer field every thirty minutes," he said in a statement at the time.

THE THREATS

The reasons for the historic decline are many. Natural events, such as regional shifts in salinity because of drought or excessive rainfall, animal foraging, storms, or disease all play a role.

Other factors may be more significant, however. Dredging channels for navigation or marinas can destroy seagrasses by removing them or covering them with sediment. Docks built over seagrass beds can shade them out. Boat propellers can shear off plants or dig them up by their roots, as can some types of fishing gear, such as oyster or clam dredges.

Those kinds of physical damage tend to occur in specific areas and at certain times of the year. Degraded water quality, however, can affect grass beds over larger areas and longer periods of time. Like any plant, the grasses

SUBMERGED AQUATIC VEGETATION

need light to photosynthesize. Too much sediment in the water can block sunlight from reaching the plants. Water enriched with too many nutrients can trigger algal blooms, which have the same effect. The sediments and nutrients come from many sources – sewage plants, eroding stream banks, rural and urban stormwater.

Runoff can also increase the amount of freshwater entering the estuaries, which can decrease salinity and harm the plants.

BRINGING THE MEADOWS BACK TO LIFE

Eelgrass, a major source of food and shelter for countless marine creatures, has all but disappeared from the inshore waters of the Northeast, but scientists and volunteers hope to restore these underwater gardens that are so vital to the health of the region's estuaries.

Narragansett Bay in Rhode Island is like so many of the area's coastal waters. Eelgrass meadows were once thought to cover as many as 100,000 acres of the bay's bottom. Less than 200 acres remained in 2001 when Save The Bay, a non-profit group, put an army of volunteers to work in a large-scale effort to turn the tide.

With initial funding support from NOAA's Community-based Restoration Program and Restore America's Estuaries, the group chose three of the most successful sites from an earlier test program for a more concentrated restoration effort. Initially, there were successes, but there was also a fair amount of heartbreak. There was, for instance, the cold winter of 2004 when ice sheets moving across the shallow water sheared off the transplanted grass, or the hot summer two years later that led to an invasion of hermit and green crabs, which uprooted the plants.

Lessons were learned and methods perfected. "All of the sites we currently plant are above 50 percent survival," noted Maria Martinez, Save The Bay's restoration ecologist. "We consider that a great success."

She's particularly encouraged by the results at Hog Island, the northernmost restoration site. The bay's northern waters are the most polluted and the eelgrass losses there the highest. The grass is very susceptible to turbidity in the water, which blocks the sun's rays, preventing photosynthesis. "The success at Hog Island is important because it may be an indication of improving water quality," Martinez said.

Ultimate success is far from assured, but there's no lack of trying. More than 200 people volunteer each year to help plant the grass. They show up, starting each spring, to help remove grass from existing healthy stands and then again to move them to the restoration sites. Each planting is a four-day exercise. "Once we harvest the eelgrass, it has to be transplanted pretty quickly," Martinez said.

Volunteers sort the harvested grass, sticking their hands in the smelly bundles hoping to avoid biting crabs and slimy sea worms. Some bring kayaks to transport the baskets of shoots to the waiting volunteer divers, who do the actual planting.

In this way, they planted more than 120,000 eelgrass shoots in 2008, the largest planting to date.

"All ages come. Entire families come," Martinez said. "There's really something for everyone to do. Without the volunteers, we couldn't do the work. It also brings an awareness of the bay and how important it is to all of us in Rhode Island."

The eelgrass restoration project in Narragansett Bay is just one of several that NOAA and RAE have helped fund. Some of the others include New Bedford Harbor in Massachusetts; tidal ponds at the Ninigret Park and National Wildlife Refuge in Charlestown, R.I.; California's Channel Islands; New Hampshire's Great Bay; San Francisco Bay; and Puget Sound.

*Waycott, Michelle, et al. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, June 29, 2009

Some Dams Have Devastating Effects on Rivers and Fish



For more than a century, America led the world in building dams. We built them to power sawmills and gristmills, to provide water for irrigation, to control flooding, to store drinking water. No one really knows how many dams stretch across our rivers, streams and creeks. The Army Corps of Engineers in the most comprehensive accounting puts the number at 75,000, but that only includes dams over six feet tall. Adding smaller dams could raise the estimate to over 2.5 million. All those dams once caused Bruce Babbitt, the former U.S. Interior secretary, to observe that we have been building, on average, one large dam a day since the Declaration of Independence.

THE VEAZIE DAM IS ONE OF THE TWO DAMS ON THE LOWER PENOBSCOT RIVER THAT WILL BE REMOVED. © Bill Curtsinger, courtesy of Penobscot River Restoration Trust

A DAM'S DAMNING EFFECTS

Blocking a moving river with a dam inherently changes the ecosystem by destroying the natural processes. Here are just a few of the effects a dam has on a river:

- Permanently inundates wildlife habitat
- Reduces water levels
- Blocks or slows river flows
- Alters timing of flows
- Alters water temperatures
- Negatively effects fish respiration
- Obstructs the movement of gravel, woody debris and nutrients
- Blocks or inhibits upstream and downstream fish passage
- Alters public river access
- Negatively affects the aesthetics and character of a natural setting

DAMS IN THE U.S.

PURPOSE	PERCENTAGE	NUMBER
Recreation	31.3	23,185
Fire & farm ponds	17.0	12,557
Flood control	14.6	10,801
Irrigation	13.7	10,176
Water supply	9.8	7,226
Tailings & other	8.1	5,967
Hydroelectric	2.9	2,166
Undetermined	2.3	1,732
Navigation	0.3	243

Source: Army Corps of Engineers National Dam Inventory

Most of those dams once served a need. Thousands were built generations ago to power mills that ushered in the Industrial Age, but the old mills are gone now or have switched to other sources of power. Some dams provided water to irrigate crops that fed a growing nation, but the cropland has been turned into shopping malls and subdivisions. Many dams are now too old to meet current safety requirements and have been abandoned by their original owners. And some dams are merely L.D.Ds, which in the dam business means “little dinky dams.” No one would miss them.

Yet, thousands of obsolete and old dams remain, capturing rivers behind stone, concrete and wood and forever changing them. “Nothing more fundamentally changes a river’s ecosystems than a dam,” notes Selena McClain of American Rivers, a conservation group that advocates for our country’s rivers.

THE THREATS

Dams do more than hold back water. They change how that water flows. They lead to increases in its temperature and alterations of its chemical composition. They can change the river’s depth and even its path. Every plant and animal species that lives along and in the river is affected, probably none more so than anadromous fish, which are ocean fish that move up freshwater rivers to spawn. The populations of salmon, steelhead trout, American shad, striped bass, sturgeon, alewife and other species have been devastated, in large part because of the dams we’ve thrown in their way.

Most of those dams have the obvious effect of stopping the fish from swimming upstream, thus blocking off more than 600,000 miles of spawning habitat nationwide. Some dams have been fashioned with fish ladders or other types of mechanisms to allow fish to pass. Many fish, however, have trouble finding the ladders or die when exposed to high water temperatures in them. Scientists believe that many of the adult fish that eventually reach their spawning grounds are often too exhausted from the journey over the dams and through the unnaturally warm reservoirs behind them to spawn successfully.

Their offspring don’t have it any easier on the return journey. Dams can significantly delay them by turning fast-flowing rivers into languid reservoirs. This delay is very harmful to the young fish as their bodies undergo physiological changes that prepare them to survive in saltwater. The stagnant

reservoirs also expose the juveniles to predators, disease and often lethally high water temperatures. If they can survive all that, the babies then risk getting cut to pieces when forced through the power turbines of hydroelectric dams.

The numbers reflect the reality. In the Pacific Northwest, Chinook, sockeye, pink, chum, and Coho salmon, along with steelhead and cutthroat trout, have all experienced dramatic declines on dammed rivers. Salmon runs that numbered in the millions before the era of dam building have now dwindled to only hundreds, and on many rivers and streams have been completely wiped out.

The story is much the same in other regions of the country. The U.S. Fish and Wildlife Service estimates that 91 percent of migratory fish habitat in northern New England is blocked by dams. These dams have contributed to the reduction of Atlantic salmon populations to less than one percent of historic levels, with the native salmon fully eliminated from many of New England's rivers. American shad and herring, which were once cultural icons in the Mid-Atlantic and Southern states, have been decimated to the point that people no longer realize how historically important they once were.

THE TRENDS

Then the Edwards Dam came down. The dam stretched across the Kennebec River in Maine, severely affecting one of the richest and most varied fisheries in the country. A coalition of four environmental groups, led by American Rivers, fought the renewal of the dam's federal license and pushed for its removal. The federal licensing agency agreed, marking the first time that it had ordered a dam be removed solely for ecological reasons. It was a turning point for river conservation.

Edwards Dam came down on July 1, 1999, opening 17 miles of the Kennebec. For the first time in 160 years, the river flowed freely from Waterville to the sea. The river's health rebounded quickly, revitalizing populations of shad, sturgeon, Atlantic salmon and striped bass. Since then, more than 600 outdated dams have been removed nationwide, and the number of recorded dam removals has grown each year, McClain said.

NOAA's Habitat Protection Division and Restoration Center, among others, have played leading roles. Through one program, its Open Rivers Initiative, regional experts are working to protect and restore access to historic migration routes and to encourage communities to help in the restoration process. NOAA also engages a large coalition of conservation organizations and community groups – including The Nature Conservancy, American Rivers, Restore America's Estuaries and the California Conservation Corp. – to work with communities during the restoration process and leverage funding for projects.

AMERICAN RIVERS LEADS DAM REMOVAL EFFORTS

American Rivers, a nonprofit conservation group, has for more than a decade been at the forefront of restoring the nation's rivers by helping remove outdated dams.

The group first got involved with dam removal with the Edwards Dam on the Kennebec River in Maine. It was the first time that the Federal Energy Regulatory Commission ordered a dam removed solely for ecological reasons. The removal in 1999 revitalized populations of migratory fish such as shad, sturgeon, Atlantic salmon and striped bass.

Since then, removing old dams has become a major project of American Rivers,

The real importance of these programs, says McClain, is felt far beyond the riverbank. In communities where dams have been removed, there is an overwhelming excitement and pride, she said.

“Removing a dam is a great opportunity for us to restore the natural environment, give something back to the community and educate people about what a natural river looks like,” she says. “To see the concrete come down and watch a river flow freely again is really quite a thrill.”



ALEWIVES MIGRATE UPSTREAM. © Margaret Pizer/The Nature Conservancy, courtesy of Penobscot River Restoration Trust

THE BENEFITS OF DAM REMOVAL

Not all, or even most, dams should be removed. But removing those that are obsolete, dangerous or too expensive to maintain can be beneficial to a river, its inhabitants and those who live along it. Those benefits include:

- Restoring river habitat
- Improving water quality
- Re-establishing migratory fish runs
- Restoring threatened and endangered species
- Removing dam safety risks and associated liability costs
- Saving taxpayer dollars
- Improving aesthetics of the river
- Improving fishing opportunities
- Improving recreational boating opportunities
- Improving public access to the river
- Improving riverside recreation
- Increasing tourism

noted Serena McClain, associate director of the group's river restoration program. She figures that since Edwards Dam the group has been directly involved or provided technical assistance in the removal of 147 dams across the country.

NOAA has helped with that effort. Since 2001, it partnered with American Rivers to help communities around the country restore their local rivers by removing unnecessary dams. This program has provided more than \$3 million in financial assistance and hours of technical assistance to more than 100 river restoration projects. The program focuses on projects that benefit anadromous fish – those that migrate between freshwater and saltwater during their life cycle, such as alewife and Atlantic salmon.



THE SETTING SUN CASTS A PURPLE GLOW ON A CANOEIST AND THE PENOBSCOT RIVER. © Joe Dana, courtesy Penobscot River Restoration Trust

Project Hopes to Save Last Wild Atlantic Salmon in America

Most Americans probably aren't aware that the salmon they buy in stores or order at restaurants were most likely raised on farms. These relatives of a magnificent wild fish that migrates 2,500 miles through the frigid waters of the North Atlantic spent their short lives in pens, swimming in endless counter-clockwise circles on a journey to nowhere.

Commercial fishing for Atlantic salmon has all but ended in the United States because so few wild fish remain. Once native to almost every river north of the Hudson, salmon have disappeared entirely from the rivers that feed Long Island Sound or drain central New England. Maine's three big rivers – the Androscoggin, the Kennebec and the Penobscot – are the last places in America where wild salmon return in any numbers to spawn, but even there they're considered endangered, as they are in the rest of their U.S. range.

The reasons are many: water pollution, changes in land uses, disappearance of the fish salmon eat, predators eating a smaller and smaller population of salmon, overfishing in the early 20th century. A map of the dams built in just Maine provides a graphic illustration of another major reason. More than 650 dams stretch across the state's rivers and streams, 116 in the Penobscot watershed alone. The dams block the returning salmon from reaching thousands of miles of spawning habitat.

In a few years, two of those dams along the lower Penobscot should disappear from the map and a fish bypass will be built around a third, opening up more than 1,000 miles of habitat for returning salmon, American shad, river herring and seven other species. The ambitious project to remove the dams, said Andy Good, may be the salmon's last hope.

"This is the best and last chance to save Atlantic salmon in the U.S.," said Good, the vice president of U.S. programs for the Atlantic Salmon Federation. "I know that's a pretty dramatic statement but the situation is dire for

salmon in the U.S., and we've put a lot of chips in this restoration project."

The federation is an international non-profit group that works to conserve wild salmon and its environment. For years, whenever a hydroelectric dam in Maine came up for relicensing, the federation and other conservation groups fought for fish passages and other concessions. In one memorable battle in the 1980s, opponents defeated a proposal to build a hydroelectric dam on the last free-flowing section of lower Penobscot.

That victory had a cathartic effect, noted Laura Rose Day, the executive director of the Penobscot River Restoration Trust. The non-profit group is coordinating the dam-removal project. "During those days, dam removal was discussed but was it beyond the sights of anyone at that point. People were facing a dam that dwarfed anything else on the river. Their main concern was stopping it," she explained. "That success then enabled people to think beyond one dam and to start thinking about what we can do to restore the river back to health."

The thinking turned to talking when PPL Corporation, a power company based in Pennsylvania, bought nine hydroelectric dams in Maine in 1999 and 2000. The company wanted to avoid more contentious relicensing fights, Good said.

"Because of the history on the river, there was an antagonistic relationship between my group and other groups and the dam owners. It was sort of scorched earth," he said. "But new owners brought a new dialogue."

From the talking came a groundbreaking agreement in 2003 between PPL and state and federal agencies, several conservation groups and the Penobscot Indian Nation. The company would sell three of its dams to the coalition for \$25 million and improve fish passage at four others. In return, PPL would be allowed to increase energy output at its remaining dams to make up for the loss and the groups would drop their opposition to the re-licensing.

Two of the dams would come down – the Veazie, which is the first barrier on the river that returning salmon encounter, and Great Works, about eight miles upstream. The dam farthest upriver, Howland, would remain but would be decommissioned and a fish passage built around it.

The announcement had special significance for Barry Dana, who was chief of the Penobscot Nation at the time. Atlantic salmon are woven into the culture of native American tribes in Maine. Yet for more than 100 years, the Penobscots couldn't exercise their tribal fishing rights to catch fish such as salmon because the river is virtually devoid of native sea-run fish.

"For 10,000 years, we have drawn our sustenance, culture and identity from this river that bears our name," Dana said at the time. "Reconnecting the Penobscot River and our reservation to the Atlantic Ocean repairs an important cycle of nature that historically allowed our tribe to survive and prosper."

The tribe and the conservation groups formed the trust to see the project through. It has successfully raised the money to buy the dams and is actively pursuing the remainder – an estimated \$30 million for dam removal and modifications, economic development and mitigation. NOAA gave the trust a \$6.1 million economic stimulus grant in 2009. It will be used to help remove the first dam, Great Works, and to pay for scientific monitoring.

The trust has applied for the necessary federal and state permits, Day said, and hopes to take down Great Works in the summer of 2010.



Removing or Reconfiguring Culverts Can Improve Fish Runs

It doesn't take tons of concrete or stone stretched across a river or stream to block fish from reaching upstream spawning grounds. Sometimes a simple pipe does the job just as well.

For decades, road engineers have commonly used culverts – concrete or corrugated metal pipes – to bridge small streams. Thousands, like the one that carried Tracyton Boulevard across Barker Creek near Bremerton in western Washington, dot the Pacific Northwest. And like the Barker Creek culvert, many cut off historic spawning grounds used by salmon and trout and are contributing to their decline.

“The philosophy behind much of the landscape development of the Puget Sound region was to turn a hilly, rocky landscape flat enough to live on,” explained Doug Myers, director of science for the advocacy group People For Puget Sound. “Most of our natural water bodies were filled. Ninety-seven percent of the marshes in central Puget Sound were filled in the first 100 years of statehood. With that kind of development legacy, there are many stream crossings that were obliterated, paved over or rerouted.”

State officials estimate that in Washington alone more than 1,800 culverts along state highways block more than 3,000 miles of potential stream habitat. Add county and town roads and those on private and federal property and the number of culverts approaches 10,000. The problem is widespread across the region. Studies found that as much as 85 percent of the culverts in western Montana blocked fish passage. Two-thirds of the culverts across salmon streams and 85 percent of those crossing trout streams in the Tongass National Forest in Alaska were found to be inadequate. Salmon biomass – the total mass of salmon – in streams in California, Oregon and Washington is 3-4 percent of historic levels. Habitat loss because of culverts is considered to be a major cause.

The Chums of Barker Creek couldn't do much about culverts in Alaska or Montana, but it could try to fix the one up the road on Tracyton Boulevard. The citizens group of about 60 people had formed in 1993 to protect a small, urban tidal creek that flows into Dyes Inlet between Bremerton and Silverdale. A bridge built in the 1800s carried the road across the creek. It was replaced in 1939 by a 90-foot long, five-foot diameter concrete pipe. The culvert was blocking Coho, chum and Chinook salmon and steelhead and cutthroat trout from moving upstream.

LEFT: THE OLD CULVERT, RIGHT, WAS REPLACED BY A MUCH WIDER CULVERT THAT ALLOWS SALMON AND TROUT TO MIGRATE UP BARKER CREEK. RIGHT: BARKER CREEK FLOWS THROUGH THE NEW, WIDE CULVERT. All photos courtesy of People For Puget Sound

The Chums called the Mid Puget Sound Fisheries Enhancement Group, one of 14 regional non-profit groups that the Washington state legislature had created to help people leverage state money with private donations for projects to improve the salmon and trout populations.

“They are a small organization with no paid staff,” said Troy Fields, the enhancement group's executive director. “They had never applied for the grant, but right from the get-go there was a local grassroots organization that was a proponent for that project. They were vital at the beginning to get the project going.”

The two groups soon found willing partners: the People For Puget Sound, Kitsap County, the Suquamish Native American tribe, Silverdale, RAE and NOAA. Using \$417,000 in state money and \$83,000 in matching contributions, they began making plans to plug the old culvert and replace it with one that is more than six times wider and 20 feet shorter. Work began in the fall of 2008 and was completed the following February.

CULVERTS AND FISH

Just one undersized or poorly maintained culvert across a stream can keep salmon or trout from reaching miles of spawning habitat.

Engineers designed culverts to do one thing: Move water under a road without flooding it. Spawning fish never entered their equations.

After heavy rains or snow melt, water can rush through an undersized culvert from upstream with force of a fire hose, making it impossible for fish to pass. The force of the water falling from the downstream end of the pipe can erode the streambed, causing a drop in elevation that even the best leaping fish can't overcome. Even if it could jump that high, the fish would have to be an exceptional marksman and hit the bull's eye – the pipe opening – to continue its journey upstream.

In saltwater streams, a small culvert will prevent the tide from thoroughly mixing the water upstream, creating a stratified water column that is detrimental to young fish that are going through physiological changes as they prepare to return to the sea. If the water upstream of the culvert is too fresh, the ecosystem will change from a salt marsh to a freshwater wetland. That, too, can be tough on returning youngsters as they try to prepare for life in saltwater.



FIDDLEHEADS BURST INTO BLOOM ALONG THE BANKS OF THE PENOBSCOT RIVER. © Joe Dana, Courtesy Penobscot River Restoration Trust

People For Puget Sound organized volunteers to place native plants on either side of the culvert to help control runoff from the hillside and the roadway. In time, Myers said, the plants will mature and their branches will provide shade and ideal water temperature for salmon traveling to and from the ocean. The plants will also be a source of food, as insects drop from the branches into the water below.

The plans for Barker Creek don't end with the culvert. The groups hope to restore the degraded creek by protecting quality habitat when possible, reducing stormwater runoff entering the stream, adding wood structures to the stream and clean gravel to some stretches to provide suitable salmon spawning habitat and restoring adjacent wetland connections to the stream.

"It's too early to know how well all this has worked," Fields said in the summer of 2009. "We have not had a fish run with the new culvert. But we expect to see an improvement."

Steve Jonn of the Chums of Barker Creek certainly hopes so. He likes to bring his four-year-old grandson to the stream to show him the salmon running, and he is eager to see the runs increase for future generations to witness.

"Hopefully we can keep this (stream) alive so my grandkid can show his kids salmon spawning in the middle of an urban area," Jonn told a newspaper reporter in early 2009.



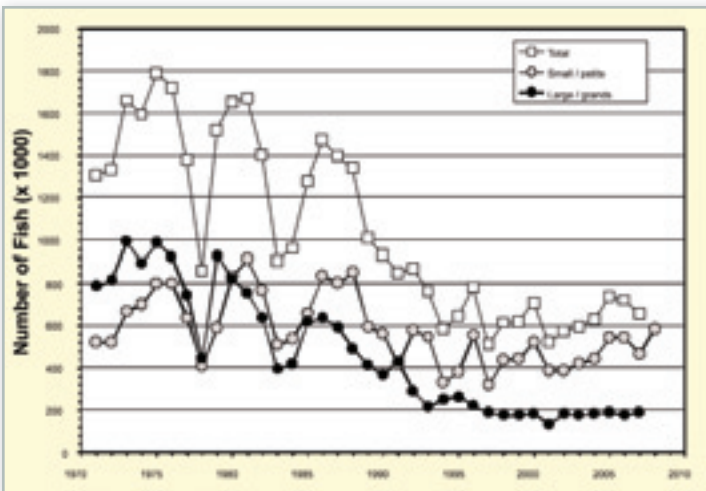
A LIGHT FALLS AS THE MORNING MIST RISES OFF THE BRANFORD SUPPLY POND. Courtesy of Save The (Long Island) Sound

Herring Making the Climb from Extinction

The pine forests that surround Branford, Conn., the soil that nurtures those trees and even the underlying bedrock itself imprint a particular scent on the waters of Queach Brook. Each spring, alewives and blueback herring, driven by internal biological forces, recognize that scent as the birthplace of their ancestors. The foot-long, silver-sided fish emerge from the salty waters of Long Island Sound and swim up the freshwater stream in search of their natal spawning grounds. For more than a century, their journey ended in vain four miles later where they ran up against civilization.

A 16-foot-high dam, built in 1899 to control flooding and store drinking water for the town, presented an impassable barrier. Thousands of dams just like it stretch across innumerable rivers and streams along the Atlantic coast. They have contributed to the decimation of alewives and blueback herring. Populations in streams and rivers that once numbered in the hundreds of thousands are now down to single digits.

River herring – the collective term for the two species – are among America's founding fisheries and are an important food for almost every fish, bird and mammal that shares the same habitat. Ospreys, bald eagles, harbor seals, sea otters, striped bass, cod and haddock are just a few of the predators that depend on these fish for their survival. Entire ecosystems could be in danger as these once abundant fish continue to vanish from their home waters.



Numbers of large and small salmon returning to North American rivers have declined markedly since 1975. The large salmon are especially important for their ability to spawn large numbers of eggs. However, numbers remain low.

Source: Atlantic Salmon Federation

In response, more and more obsolete dams are being removed to reopen historic spawning grounds. That wasn't an option in Branford, a town of about 30,000 a few miles east of New Haven. It still relies on the 17-acre impoundment behind the dam for its drinking water. If the herring were to continue their journey, a way had to be found around the dam.

Oddly, the idea of a herring revival sprang from the town's effort to protect its source of drinking water. A developer in the late 1990s proposed building an 18-hole golf course and a residential subdivision on 240 acres about a half-mile upstream from the dam. The tract was in the middle of the cleanest water remaining in the Branford River basin. Three natural ponds dotted the area, including Linsley Pond, where Dr. G. Evelyn Hutchinson, the legendary limnologist from nearby Yale University, conducted many classic research studies in the 1930s and '40s. Opponents feared that sedimentation during construction on the steep, hilly land and stormwater runoff from the completed development would foul the town's drinking water source.

The local wetlands agency denied the developers' request to build in the wetlands on the property. The developers sued, and the case attracted conservation groups like Save The Sound and land preservationists, which supported the town. The Connecticut Supreme Court ultimately upheld the agency's decision, and the developers eventually sold most of the land to the town and the Branford Land Trust.

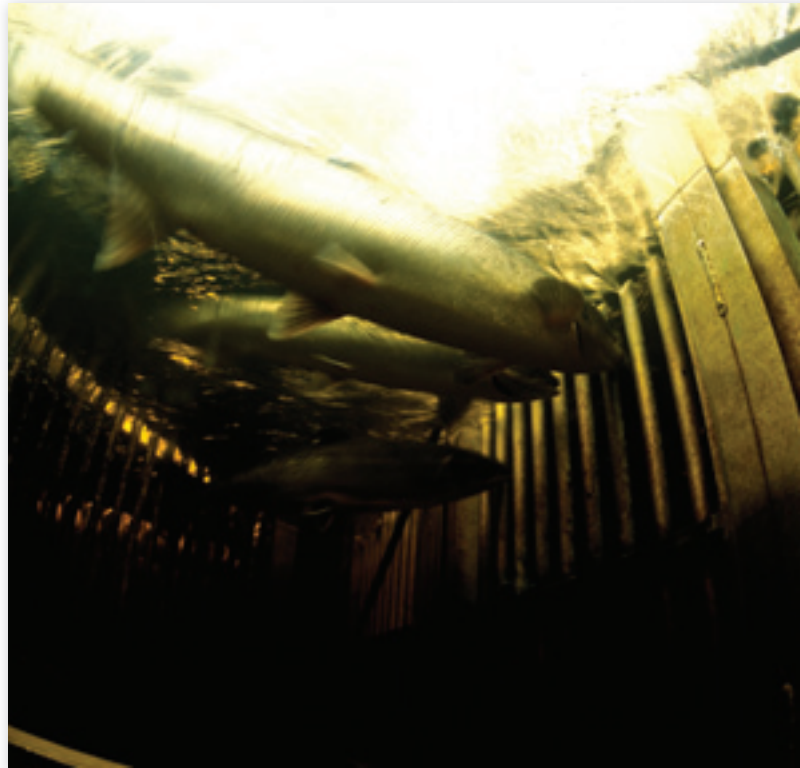
"It's an interesting evolution," noted Chris Cryder, director of restoration and stewardship for Save The Sound, now part of the Connecticut Fund for the Environment. "A development issue that non-profits advocated against and intervened in support of the town's decision ultimately led to protection, and citizens rallied around that."

Once the land was saved, attention shifted to saving the river herring. The land trust joined with the Branford Rotary Club in 2003 to begin planning to install an artificial channel, called a fish ladder or fishway, to allow the herring to bypass the dam. Other partners soon joined the effort, including the town, Save The Sound, Restore America's Estuaries, the U.S. Fish & Wildlife Service, Yale University and the state's Inland Fisheries Division, which identified the waters above the dam as one of its priority sites for restoring fish populations. Grants from the NOAA Restoration Center, in partnership with RAE, matched by corporate contributions through the Connecticut Corporate Wetlands Restoration Partnership provided the \$203,000 for the project.

The 90-foot-long aluminum fish ladder was completed in the spring of 2006, connecting Queach Brook to almost 100 acres of open water and five miles of river and stream habitat behind the dam. The ladder consists of a series of baffles that slows down the flow to allow the fish to navigate upstream. The tiered design also gives them level pools to rest in while making the journey.

An electronic counter installed by scientists at Yale University has recorded more and more herring passing through the ladder each spring. About 4,000 made the trip in 2009. Those numbers are expected to grow dramatically in the next few years as the herring born above the dam since the ladder opened return to spawn.

"The numbers are now small but the increase is in a positive direction," said Curt Johnson, director of programs for Save the Sound and the Connecticut Fund for the Environment. "It's often a 20-year process. It took decades to screw this up and it will take time to bring things back."



SALMON ENTER THE FISH LADDER AT THE VEAZIE DAM. © Bill Curtisinger, courtesy of Penobscot River Restoration Trust

FISH LADDER DESIGNS

Fish ladders are also known as fish steps or fishways. They are artificial structures built around barriers in a river or stream, such as dams or locks, that allow fish to get around the barrier. There are five main types:

- **BAFFLES:** Uses a series of symmetrical close-spaced baffles in a channel to redirect the flow of water, allowing fish to swim around the barrier. Pools can be included to provide a resting area or to reduce the velocity of the flow. Baffles come in variety of designs. The original design was developed in 1909 by G. Denil, a Belgian scientist. It has since been adjusted and adapted in many ways. The "Alaskan Steeppass," for example, is a modular prefabricated Denil-fishway variant originally designed for remote areas of Alaska.
- **POOL AND WEIR:** One of the oldest styles of fish ladders, this design uses a series of small dams and pools of regular length to create a long, sloping channel for fish to travel around the obstruction. The channel gradually steps down the water level, and fish must jump from pool to pool in the ladder to head upstream,
- **ROCK-RAMP:** Uses large rocks and timbers to create pools and small falls that mimic nature. These are used to bypass relatively short barriers because of the length of the channel needed for the ladder.
- **VERTICAL-SLOT:** This design is similar to a pool-and-weir system, except that each dam in the ladder has a narrow slot in it near the channel wall, which allows fish to swim upstream without leaping over an obstacle.
- **ELEVATOR OR LIFT:** As its name implies, this design provides a sort of elevator to carry fish over a dam. Fish swim into a collection area at the base of the dam. When enough fish enter the area, they are nudged into a hopper that carries them into a flume that empties into the river on the other side of the dam. It's usually used for tall dams.

BARRIER ISLANDS: Coastal Protectors



They have been likened to jewels, touted as paradises and described as restless ribbons and lonely sentinels. Whatever you call them, however, America's barrier islands are among the country's most important coastal features.

Running more than 3,500 miles along the Atlantic and Gulf coasts, these islands are just what their name implies: barriers. They guard our coastlines, providing invaluable buffers to vulnerable shores and inland areas from violent storms and waves.

A barrier island is a narrow island of sand that forms parallel to the shoreline. They aren't anchored on bedrock; like their smaller cousins, spits and shoals, they are essentially big sandbars.

In its simplest form, a barrier island consists of shallow beach facing out into open ocean; a central dune (or dunes) running the length of the island and dividing it in two; a low-lying overwash area – often a mud flat; and a salt marsh forming on the landward side of the island, abutting a shallow lagoon, sound or bay separating it from the mainland. These salt marshes are among the most ecologically productive places on Earth.

Barrier islands are relative newcomers to the world stage. While theories vary, many geologists believe that barrier islands began forming at the end of the last ice age, 15,000 years ago. As the glaciers receded and sea levels rose, new coastlines formed, leaving shallow dunes offshore. Rising waters, waves and currents fed sediments to these newborn islands.

Though we like to think that these islands are permanent, they are not. In fact, barrier islands are among the most changeable environments on Earth.

Because they are loose aggregations of sand and fill, barrier islands are dynamic. Tides and storms routinely rearrange them, shifting and removing sand, forming and reforming the shape and structure of each island. Geologically ephemeral, the islands wax and wane in response to the rise and fall of sea levels. As ocean levels rise and the continental coast behind the islands retreats, barrier islands can "migrate" toward the receding shoreline, losing ocean-side beach as the waters rise, particularly

during storms, and gaining new sand on the landward side, following the coast in a millennial rhythm.

And, occasionally, they disappear altogether. In one famous recent instance, an entire chain of uninhabited barrier islands off the Louisiana-Mississippi coast, the Chandeleurs, vanished almost completely in a relative heartbeat, a victim of Hurricanes Dennis and Katrina in 2005. Today the Chandeleurs, a fraction of their former selves, consist mostly of tattered islets and underwater shoals.

While we often think of their central role as protectors of our coasts, barrier islands are also havens, providing refuge and habitat for thousands of species of plants and animals, and serving as stopovers for many kinds of migrating birds who depend on the islands for rest, food and water during their journeys.

TRENDS AND THREATS

Increasingly, these fragile islands are also providing havens for Americans in the form of homes, resorts and vacation spots.



TOP LEFT: GRANDE ISLE TOP RIGHT: BARRIER ISLAND PLAQUEMINES PARISH
BOTTOM: CAPE HATTERAS NATIONAL SEASHORE *Courtesy Bill Russ*

More than 400 major barrier islands line the East and Gulf coasts, from New England to Mexico. Among the most notable are Cape Cod in Massachusetts; New Jersey's Long Beach; Assateague Island in Maryland and Virginia; North Carolina's famous Outer Banks; South Carolina's world-class resorts, Hilton Head and Pawley's islands; Jekyll and the Sea Islands in Georgia; Amelia, Captiva, Key Biscayne, Palm Beach, Sanibel and Miami Beach in Florida; and Galveston, Matagorda and Padre islands in Texas.

Some of these barrier islands are among the most populated, most developed and, consequently, some of the most threatened inhabited sites in North America.

In fact, over the past 60 years, America's barrier islands have been at the center of a real-estate boom. Between 1950-1975—a period that coincides with the post-War economic boom—urban development on coastal islands in the United States increased 150 percent. More than half of the U.S. population now lives in coastal counties. According to one recent study, the permanent population of those counties is increasing by an astounding 3,600 new residents a day.

Barrier islands are at risk from natural erosion from tides and storm and, increasingly, from rising sea levels due to climate change.

While estimates vary, many scientists peg current sea-level rise at about an eighth of an inch annually, imperceptible to the casual observer, but very noticeable on low-lying barrier islands that seldom top-out at more than a few feet above sea level. As the air temperature rises this century, so will the ocean level, though more slowly. Every careless cook who failed to keep an eye on a pot of boiling spaghetti water knows all about thermal expansion. Add water from melting glaciers, and sea level could rise as much as 10 inches by 2030 and three feet by 2100 – about twice the current rate.

Although a foot or two of sea level rise may not sound like much, the effect could be severe. For example, computer models done at Duke University show that a 13.7-inch sea level rise would inundate about 770 square miles of the N.C. coast, an area nearly the size of Great Smoky Mountains National Park. North Carolina's coastal wetlands and other low-lying areas could be inundated, much of the Outer Banks would disappear, and the Albemarle and Pamlico sounds could merge with open waters that Dr. Stan Riggs, a geologist at East Carolina University, calls "Pamlico Bay."

A warmer world also means warmer seas which generate more storms and more violent storms. The Atlantic seaboard and Gulf Coasts are too often ground zero for hurricanes which erode, rearrange, move and occasionally destroy barrier islands outright.

As the islands have thinned, we have tried to prevent the migration, and sometimes the outright loss, of beach and land, through groins, levees, jetties, and breakwaters. As beaches have eroded, we have replaced them wholesale by pumping sand on them, a process known as "beach nourishment."

In the end, these may be temporary "fixes."

Chaland: Rebuilding Barrier Islands

Shielding our coasts from Maine to Texas, barrier islands play an essential role in protecting America's coastlines and providing habitat for wildlife. Their importance is recognized all over the world, but barrier islands are most beneficial in areas where rising sea levels and storms affect coastlines.

Because of frequent hurricanes in the Gulf of Mexico, development, oil and gas activities, diminishing sediment deposition from the Mississippi River and other Gulf feeders and climate change, Louisiana has one of the highest rates of shoreline erosion in the world, ranging from twenty to 100 feet a year.

As a result, the Chaland Headland barrier islands in Plaquemines Parish about 60 miles south of New Orleans have almost completely vanished. NOAA, with partners that include the Louisiana Department of Natural Resources, the Army Corps of Engineers, Plaquemines Parish and the University of New Orleans, undertook the largest barrier island restoration projects ever attempted by the agency.

This three-mile long project's primary purpose is to prevent breaching of the barrier shoreline and to protect and create habitats. The Chaland Headlands provide shelter and food for a variety of shoreline birds and wildlife that are vital to coastal Louisiana. Reconstructing the system of wetlands nourished by the Mississippi River is critical for estuarine fish and shellfish populations and will help protect coastal communities.

The Chaland Headlands project will ultimately restore about 180 acres of dune and beach, along with 246 acres of inter-tidal salt marsh. Sand and silt will be mined from an offshore area in the Gulf of Mexico to restructure the dunes and marsh.

In early 2007, NOAA completed the first phase of the project by pumping more than 1.7 million cubic yards of sand to reconnect the three island sections that were left after Hurricane Katrina roared through two years earlier. This phase saw more than 1,200 acres of coastal habitat restored, and the Chaland Headlands Restoration project was named one of America's Top Restored Beaches by the American Shore and Beach Preservation Association.

The Chaland Headlands Restoration project certainly has had its fair share of challenges. The project began just four days before Katrina made landfall just eight miles away. Human factors and ecological changes have helped divide the islands into three small fragments, increasing the tiny archipelago's vulnerability to storm surge and erosive forces that threaten to wear away coastal wetlands.

Over a 20-year period, the Chaland Headlands Restoration project should restore more than 330 acres of barrier island and coastal wetlands at a cost of \$76 million. Fighting both the destructive capabilities of human- and storm-caused agencies is likely to be an ongoing battle with this project, but restoring these crucial barrier islands is and will be a great asset for the critically threatened Louisiana coast.



SATELLITE VIEW OF NORTH CAROLINA'S BARRIER ISLANDS



Protecting a Scenic Highway and Restoring a Lakeshore

Lake Superior, with the largest surface area of a freshwater lake in the world, is often overlooked as having a pristine, stunning shoreline; but if you ask any of the occupants of the 3 million cars that travel alongside it every year, they will tell you otherwise.

The lake's natural beauty has been evident for centuries. In 1919, the Michigan State Highway M-28 was built beside the southern shore of Lake Superior stretching from Wakefield to near Rosedale. M-28, together with U.S. 2, forms a pair of main highways connecting the Upper Peninsula from end to end, providing a major access route for traffic from Michigan and Canada.

Because of its vicinity to the shoreline, M-28 is considered to be part of the Superior Lake Circle Tour; where travelers can drive beside the lake. In addition to incredible scenic shoreline views, the highway also passes through woodland forests, swamps and urban areas.

The Pictured Rocks National Lakeshore and the lakeside town of Marquette are directly off of M-28, offering dramatic sceneries, public rest areas and easy shore access; which in return, leads to millions of visitors each year.

In recent years, the wear and tear of the highway near the lake's shoreline has been threatening public safety. Gusting winds from the lake carry sand and snow onto the road causing severe erosion. Road closures are a frequent occurrence, as is damage to nearby homes and dune habitats.

Local organizations and the public began to take note of these problems, and with funding by NOAA, created the Lake Superior Dune Restoration and Public Access Project. This project has restored sand dunes and planted seagrass, trees and other native plants to control erosion and prevent the strong winds from further damaging the highway and harming the public.

The project also took the public's interest into account and constructed a scenic overlook and pedestrian access to Lake Superior's shoreline.

While maintaining the efforts of the Lake Superior Dune Restoration and Public Access Project, the southern shore of Lake Superior should continue to attract visitors for years to come. These steps should allow the growth of wildlife habitats, endless scenic views and public enjoyment to flourish.

SAVING THE CHIWAUKEE *continued from page 11*

confidence, and he was very good at organizing people."

Itis gave Krampert his files on the Chiwaukee and his marching orders. "It's up to you people now to save that prairie," he told him.

But how?

The Chiwaukee gave them the answer. Sander and Krampert spent that May day in 1965 walking through the tall grass and shooting stars, studying maps that showed the 1,200 privately owned lots in the prairie. Above them, upland plovers plunged to earth in majestic dives. Bobolinks and marsh hens chattered incessantly all around them.

They identified a thin strip of land, about 15 acres, in the middle of the proposed marina development. Somehow, the developers had overlooked it. Buying it could stop the marina.

They stood at the railroad tracks in the fading light debating how to raise the money. Would people donate to save what many considered a patch of noxious weeds? It was the kind of challenge no one had taken up before.

"Al, we've got to start somewhere," Sander said, "and the only way we'll ever know if it can be done is by trying."

The Wisconsin Chapter of The Nature Conservancy, which would remain a steadfast partner over the next four decades, agreed to lend Krampert's committee \$5,500 to buy the errant strip. By the end of 1966, the committee raised more than \$26,000, and 74 acres of the precious prairie were preserved. The marina project fizzled.

It was only the beginning. "The number of owners involved was the greatest obstacle," Krampert wrote. "They were literally scattered all over the four corners of the Earth."

Most were contacted over the next 40 years, and little by little, acre by acre, the prairie was saved. More than 500 acres are now preserved and owned by the state, the conservancy or the University of Wisconsin.

The Chiwaukee Prairie exists today because of the will of determined people like Phil Sander and Al Krampert who had a vision of the possible, noted Richter. "They had a great combination of passion and advocacy. And they could build a coalition," he said. "These people had no scientific background, but they knew this was a very special place and they could excite the academics in the 1960s to really go to bat for them."

Krampert died in 1994 and the main road into the prairie was renamed in his honor.

Forever a student of nature and natural history, Sander unearthed a fossil that led to the discovery, some 30 years later, of two complete woolly mammoth skeletons near Kenosha that are now major attractions at the town's museum. He died in 2006 at age 99. The University of Wisconsin created a scholarship in his honor, and birding trails and natural areas around Kenosha bear his name.

STORMWATER AND SHELLFISH *continued from page 15*

In a natural coastal setting, the ground soaks up rain. It is taken up by plants, evaporates or slowly makes its way to underground aquifers. Very little of it overflows into waterways. In our cities, towns and neighborhoods, we cover the land with concrete and asphalt and have devised an elaborate system of pipes and ditches designed to get the rain off our property and streets as quickly as possible. We have become very good at it.

The rain running off these hard surfaces mysteriously disappears down a drain and re-emerges untreated from a pipe at a river, creek or bay. It brings with it the fertilizers, pesticides, petroleum products, bacteria and other pollutants that it has picked up on its journey. If enough of this stormwater enters the water, the oysters and clams growing there will become unsafe to eat because of high bacteria levels, forcing state health officials to close the contaminated beds for harvest.

Found in the digestive tracts of all warm-blooded animals, these bacteria are everywhere, as Dr. Bill Kirby-Smith has learned during a career spent studying stormwater's effects on coastal estuaries. People too often focus on the sources of bacteria, said Kirby-Smith, a professor and researcher at the Duke University Marine Lab near Beaufort, N.C. They are ubiquitous and mostly natural. Except from the occasional failing septic tank or malfunctioning sewer plant, the bacteria don't normally pollute the water because on an undisturbed, natural landscape they usually don't make it there.

"I focused on the sources when I first started," Kirby-Smith said. "It's only after I started working on this that I learned that, yes, you can concentrate sources. These are sources that are present in an unaltered watershed but the bacteria just didn't get transported to the water. The alteration of the landscape conveys the bacteria in some fashion."

Research done at the University of North Carolina-Wilmington, the College of Charleston (S.C.) and elsewhere shows that roads and other types of impervious surfaces are the kind of landscape alterations that can create runoff and move it quickly to the surrounding water. Pave over enough of a watershed and the water becomes so laden with bacteria, regardless of the sources, that the oysters and clams are unsafe to eat. Those studies show that bacteria concentrations in the water and shellfish closures increase with the amount of hard, or impervious, surfaces in a watershed. Water quality begins to deteriorate when as little as 10 percent of the watershed is paved and stormwater isn't controlled. Bacteria levels get high enough to close shellfish beds at 12 percent to 15 percent impervious surface.

THE HEALING OF SAN FRANCISCO BAY BEGINS
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Converting the salt ponds to tidal marsh will begin to restore the natural balance of San Francisco Bay, Lewis said, but 100,000 acres of marsh is needed to make the bay ecologically healthy again. Save The Bay's report, *Greening the Bay*, gives a detailed look at what it would cost to restore the remaining acres. The report is available online at www.savesfbay.org.

Ritchie figures that the first phase of the South Bay project will cost \$38 million. It should be done by 2015, he said, and then the project will be evaluated to see what methods and types of restoration work best. It will probably take 30 years to finish, he said, and the cost will approach \$1 billion.

"In a way we're lucky that these lands were converted to salt ponds," he said. "If they hadn't been, the land would have been turned into residential or commercial developments, and we would now have nothing to save."

WANT TO KNOW MORE?

- NOAA Office of Habitat Conservation: www.nmfs.noaa.gov/habitat
- Restore America's Estuaries: www.estuaries.org
- American Littoral Society: www.littoralsociety.org
- Chesapeake Bay Foundation: www.cbf.org
- Coalition to Restore Coastal Louisiana: www.crcl.org
- Connecticut Fund for the Environment: www.ctenvironment.org
- Conservation Law Foundation: www.clf.org
- Galveston Bay Foundation: www.galvbay.org
- North Carolina Coastal Federation: www.nccoast.org
- People For Puget Sound: www.pugetsound.org
- Save The Bay – San Francisco: www.savesfbay.org
- Save The Bay – Narragansett Bay: www.savebay.org
- Tampa Bay Watch: www.tampabaywatch.org

Wetlands

- U.S. Geological Survey: www.npwrc.usgs.gov/resource/wetlands/wetloss/
- National Wetlands Inventory: www.fws.gov/wetlands/Data/index.html

Chicauwee Prairie

- Chicago Wilderness Magazine: chicagowildernessmag.org/issues/summer2002/IWchicauwee.html
- Prairie Pages blog: prairiepages.blogspot.com
- Chicauwee Prairie Preservation Fund: www.chicauwee.org
- Wisconsin Department of Natural Resources: www.dnr.state.wi.us/org/LAND/er/sna/sna54.htm

North River Farms Restoration

- N.C. Coastal Federation: www.nccoast.org/restoration-education/
- Restoration Systems: www.restorationsystems.com/news/index.asp?ID=16
- North Carolina Shellfish Sanitation and Recreational Water Quality Section: www.deh.enr.state.nc.us/shellfish/shellfish.htm
- North Carolina State University Biological and Agricultural Engineering Department, Dr. Michael R. Burchell II: www.bae.ncsu.edu/people/faculty/mrburche/
- Duke University Marine Laboratory, Dr. Bill Kirby-Smith: fds.duke.edu/db/Nicholas/msc/faculty/wwwks/research.html
- NOAA Community-based Restoration Center: www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/index.html

San Francisco Bay Salt Ponds

- South Bay Salt Pond Restoration Project: www.southbayrestoration.org
- Cargill Salt: www.cargill.com/static/sb/

Seagrasses

- Encyclopedia of the Earth: www.eoearth.org/article/Seagrass_meadows
- World Seagrass Association: wsa.seagrassonline.org
- Proceedings of the National Academy of Sciences: www.pnas.org/search?fulltext=seagrasses&submit=yes&go.x=6&go.y=8

Narragansett Bay Restoration

- Save The Bay: www.savebay.org
- YouTube video: www.youtube.com/watch?v=xoeDHHfO9tg

Dam Removal

- American Rivers: www.amrivers.org

Penobscot River

- Penobscot River Restoration Trust: www.penobscotriver.org

